PHASE **2**

Washington State
School Seismic Safety Assessments Project

CENTRAL ELEMENTARY SCHOOL MAIN BUILDING

Hoquiam School District #28

SEISMIC UPGRADES CONCEPT DESIGN REPORT

June 2021

PREPARED FOR

PREPARED BY

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WASHINGTON STATE SCHOOL SEISMIC SAFETY ASSESSMENTS PROJECT

SEISMIC UPGRADES CONCEPT DESIGN REPORT

Central Elementary School – Main Building

Hoquiam School District #28

June 2021

Prepared for:

State of Washington
Department of Natural Resources and Office of Superintendent of Public Instruction

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EXECUTIVE SUMMARY

This report documents the findings of a seismic evaluation of the Central Elementary School Main Building in Hoquiam, Washington. Central Elementary is a single-story building constructed in 1952. The core of the building appears to be a cast-in-place concrete structure with concrete sawtooth roof. There is a rectangular, wood-framed, flat-roof classroom wing at the north end of the facility. At the east end of the facility there is another rectangular footprint wood-framed, flat-roofed wing housing the gymnasium and kitchen spaces. The total footprint area is a cross between a "C" shape and a rectangle, with an approximate gross area of 39,000 square feet. The typical roof height appears to be about 15 feet, although there are several roof planes, especially at the gymnasium. Apparently, there was a modernization in 2000; however, it is unclear if any structural retrofits were made at that time.

WSP USA, Inc., performed a Tier 1 screening in accordance with the ASCE 41-17 standard *Seismic Evaluation and Retrofit of Existing Buildings*. The evaluation included field observations and review of record drawings to verify the existing construction. The structural seismic evaluation indicated that the building has multiple seismic deficiencies; the most susceptible ones being overturning and shear stresses at the narrow concrete piers of the sawtooth building structure and excessive diaphragm spans at the straight-sheathed, wood-framed, low-slope roofs. There are also several items that were marked unknown due to a lack of available as-built information. Further investigation is recommended to resolve these “unknown” items.

Conceptual seismic upgrade recommendations for the structural systems are provided to improve the performance of the building to meet the Life Safety structural performance objective criteria of ASCE 41-17. Sketches for the concept-level seismic upgrades are provided in Appendix B. The structural upgrades include adding additional length of shear wall and strongbacking existing piers; and adding diaphragm anchors and new wood structural panel sheathing at the wood-framed flat roofs. New foundations will be necessary where shear wall will be added. Due to suspect soils, jet grouting to mitigate liquefaction as well as pin-piling will be needed at each location. The recommendations for nonstructural upgrades are to further investigate the bracing and flexible coupling requirements for fire suppression piping. Also, tall and narrow contents, such as tall bookshelves, as well as heavy items and other fall-prone contents located higher than 4 feet above the floor should be anchored or braced to the structure.

An opinion of probable construction costs is provided in Appendix C. It is our opinion that the total cost (construction costs plus soft costs) to upgrade the structure would range between $4.27M and $8.01M with the baseline probable total cost being $5.34M.

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Acronyms

AACE	Association for the Advancement of Cost Engineering
ADA	Americans with Disabilities Act
ASCE	American Society of Civil Engineers
A-E	Architects-Engineers
BPOE	Basic Performance Objective for Existing Buildings
BSE	Basic Safety Earthquake
BU	Built-Up
CMU	Concrete Masonry Unit
CP	Collapse Prevention
DNR	Department of Natural Resources
DCR	Demand-to-Capacity Ratio
EERI	Earthquake Engineering Research Institute
EPAT	EERI Earthquake Performance Assessment Tool
FEMA	Federal Emergency Management Agency
GC/CM	General Contractor / Construction Manager
GWB	Gypsum Wallboard
IBC	International Building Code
ICOS	Information and Condition of Schools
IEBC	International Existing Building Code
IO	Immediate Occupancy
LS	Life Safety
MCE	Maximum Considered Earthquake
MEP	Mechanical/Electrical/Plumbing
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
OSPI	Office of Superintendent of Public Instruction
PBEE	Performance-Based Earthquake Engineering
PR	Position Retention
ROM	Rough Order-of-Magnitude
SSSSC	School Seismic Safety Steering Committee
UBC	Uniform Building Code
URM	Unreinforced Masonry
USGS	United States Geological Survey
WF	Wide Flange
WGS	Washington Geological Survey
WSSSSAP	Washington State School Seismic Safety Assessments Project

Reference List

Codes and References

2018 IBC, *2018 International Building Code,* prepared by the International Code Council, Washington, D.C.

AACE International Recommended Practice No. 56R-08, 2020, *Cost Estimate Classification System*, prepared by the Association for the Advancement of Cost Engineering International, Fairmont, West Virginia.

ASCE 7-16, 2017, *Minimum Design Loads for Buildings and Other Structures*, prepared by the Structural Engineering Institute of the American Society of Civil Engineers, Reston, Virginia.

ASCE 41-17, 2017, *Seismic Evaluation and Retrofit of Existing Buildings*, prepared by the Structural Engineering Institute of the American Society of Civil Engineers, Reston, Virginia.

FEMA E-74, 2011, *Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide*, prepared by Applied Technology Council, Redwood City, California.

Structural Engineers of Northern California, 2017, Earthquake Performance Rating System ASCE 41-13 Translation Procedure: The Buildings Ratings Committee, a sub-committee of the Existing Buildings Committee of The Structural Engineers Association of Northern California.

Structural Engineers of Northern California, 2015, Earthquake Performance Rating System User's Guide: The Buildings Ratings Committee, a sub-committee of the Existing Buildings Committee of The Structural Engineers Association of Northern California.

Drawings

No original construction drawings were available for review for the seismic evaluation and development of this conceptual seismic upgrade report. Structural system descriptions and seismic deficiencies are based on limited field observation only and the engineers' experience with buildings of similar construction type and vintage.

A general floor plan provided by the Office of Superintendent of Public Instruction (OSPI) however is included in Appendix E.

1.0 Introduction

1.1 Background

In 2018-2019, the Washington Geological Survey (WGS), a division of the Department of Natural Resources (DNR), led a Washington State School Seismic Safety Assessments Project (WSSSSAP) that seismically and geologically screened 222 school buildings and 5 fire stations across Washington State to better understand the current level of seismic risk of Washington State's public-school buildings. This first phase of the WSSSSAP was executed with the help of Washington State's Office of Superintendent of Public Instruction (OSPI) and Reid Middleton, along with their team of structural engineers, architects, and cost estimators.

Building upon the success of Phase 1, WGS, OSPI, and Reid Middleton's team embarked on Phase 2 of this project to seismically and geologically screen another 339 school buildings and 2 fire stations, mostly located in the high-seismic risk regions of Washington State. Similar to Phase 1, the two main components of Phase 2 of this seismic safety assessments project are: (1) geologic site characterization, and (2) the seismic assessment of buildings. As a part of the seismic assessments, Tier 1 screening of structural systems and nonstructural assessments were performed in accordance with the American Society of Civil Engineers' (ASCE) Standard 41-17 *Seismic Evaluation and Retrofit of Existing Buildings*. Concept-level seismic upgrades were developed to address the identified deficiencies of a select number of school buildings to evaluate seismic upgrade strategies, feasibilities, and implementation costs.

Seventeen school buildings were selected in consultation with WGS and OSPI to receive concept-level seismic upgrade designs utilizing the ASCE 41 Tier 1 evaluation results. This report documents the concept-level seismic upgrade design for one of those school buildings. The concept-level seismic upgrades will include structural and nonstructural seismic upgrade recommendations, with concept-level sketches and rough order-of-magnitude (ROM) construction costs determined for each building. The 17 school buildings were selected from the list of schools with the intent of representing a variety of regions, building uses, construction eras, and construction materials.

The overall goal of the project is to provide a better understanding of the current seismic risk of our state's K-12 school buildings and what needs to be done to improve the buildings in accordance with ASCE 41 to meet seismic performance objectives.

The seismic evaluation consists of a Tier 1 screening for the structural systems performed in accordance with ASCE 41-17.

1.2 Scope of Services

The project is being performed in several distinct and overlapping phases of work. The scope of this report is as listed in the following sections.

1.2.1 Information Review

1. Project Research: Reid Middleton and their project team researched available school building records, such as relevant site data and record drawings, in advance of the field investigations. This research included searching school building records and contacting the districts and/or the Office of Superintendent of Public Instruction (OSPI) to obtain building plans, seismic reports, condition reports, or related construction information useful for the project.

2. Site Geologic Data: Site geological data provided by the WGS, including site shear wave velocities, was utilized to determine the project Site Class in accordance with ASCE 41, which is included in the Tier 1 checklists and concept-level seismic upgrades design work.

1.2.2 Field Investigations

1. Field Investigations: Each of the identified buildings was visited to observe the building's age, condition, configuration, and structural systems for the purposes of the ASCE 41 Tier 1 seismic evaluations. This task included confirmation of general information in building records or layout drawings and visual observation of the structural condition of the facilities. Engineer field reports, notes, photographs, and videos of the facilities were prepared and utilized to record and document information gathered in the field investigation work.

2. Limitations Due to Access: Field observation efforts were limited to areas and building elements that were readily observable and safely accessible. Observations requiring access to confined spaces, potential hazardous material exposure, access by unsecured ladder, work around energized equipment or mechanical hazards, access to areas requiring Occupational Safety and Health Administration (OSHA) fall-protection, steep or unstable slopes, deteriorated structural assemblies, or other conditions deemed potentially unsafe by the engineer were not performed. Removal of finishes (e.g., gypsum board, lath and plaster, brick veneer, roofing materials) for access to concealed conditions or to expose elements that could not otherwise be visually observed and assessed was not performed. Material testing or sampling was not performed. The ASCE 41 checklist items that were not documented due to access limitations are noted.

1.2.3 Seismic Evaluations and Conceptual Upgrades Design

1. Seismic Evaluations: Limited seismic assessments of the structural and nonstructural systems of the school buildings were performed in accordance with ASCE 41-17 Tier 1 Evaluation Procedures.

2. Conceptual Upgrades Design: Further seismic evaluation work was performed to provide concept-level seismic retrofits and/or upgrade designs for the selected school buildings based on the results of the Tier 1 seismic evaluations. The concept-level seismic upgrades design work included narrative descriptions of proposed seismic retrofits and/or

upgrade schemes and concept sketches depicting the extent and type of recommended structural upgrades.

3. Architectural Review: The seismic upgrade concept developed by the structural engineers was reviewed by Rolluda Architects, Inc., for general guidance and consideration of the architectural aspects of the seismic upgrade. The architects discussed the seismic upgrade concepts with the structural engineer and reviewed existing drawings that were available, pictures taken during the engineer's field investigations, and the ASCE 41 Tier 1 Screening reports. However, field visits by the architect and meetings with the school district and facilities personnel to discuss phasing and programming requirements were not included in the project scope of work. The architectural considerations are discussed in Section 4.4 Nonstructural Recommendations and Considerations. These conceptual designs were reviewed with high-level recommendations. Future planning for seismic improvements should include further review with a design team.

4. Cost Estimating: Through the concept-level seismic upgrades report process, ProDims, LLC, provided opinions of probable construction costs for the concept-level seismic upgrade designs for the selected school buildings. These concept-level seismic upgrade designs and the associated opinions of probable construction costs are intended to be representative samples that can be extrapolated to estimate the overall capital needs of seismically upgrading Washington State schools.

1.2.4 Reporting and Documentation

1. Conceptual Upgrade Design Reports: Buildings that were selected to receive a conceptual upgrade design will have a report prepared that will include an introduction summarizing the overall findings and recommendations, along with individual sections documenting each building's seismic evaluation, list of deficiencies, conceptual seismic upgrade sketches and opinions of probable construction costs.

2. Building Photography: Photos were taken of each building during on-site walkthroughs to document the existing building configurations, conditions, and structural systems. These are available upon request through DNR/WGS.

3. Existing Drawings: Select and available existing drawings and other information were collected during the evaluation process. These are available upon request through DNR/WGS.

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2.0 Seismic Evaluation Procedures and Criteria

2.1 ASCE 41 Seismic Evaluation and Retrofit Overview

The current standard for seismic evaluation and retrofit (upgrades) of existing buildings is ASCE 41-17. ASCE 41 provides screening and evaluation procedures used to identify potential seismic deficiencies that may require further investigation or hazard mitigation. It presents a three-tiered review process, implemented by first following a series of predefined checklists and "quick check" structural calculations. Each successive tier is designed to perform an increasingly refined evaluation procedure for seismic deficiencies identified in previous tiers in the process. The flow chart in Figure 2.1 illustrates the evaluation process.

TIER 1 – Screening Phase
- Checklists of evaluation statements to quickly identify potential deficiencies
- Requires field investigation and/or review of record drawings
- Analysis limited to "Quick Checks" of global elements
- May proceed to Tier 2, Tier 3, or rehabilitation design if deficiencies are identified

TIER 2 – Evaluation Phase
- "Full Building" or "Deficiency Only" evaluation
- Address all Tier 1 seismic deficiencies
- Analysis more refined than Tier 1, but limited to simplified linear procedures
- Identify buildings not requiring rehabilitation

TIER 3 – Detailed Evaluation Phase
- Component-based evaluation of entire building using reduced ASCE 41 forces
- Advanced analytical procedures available if Tier 1 and/or Tier 2 evaluations are judged to be overly conservative
- Complex analysis procedures may result in construction savings equal to many times their cost

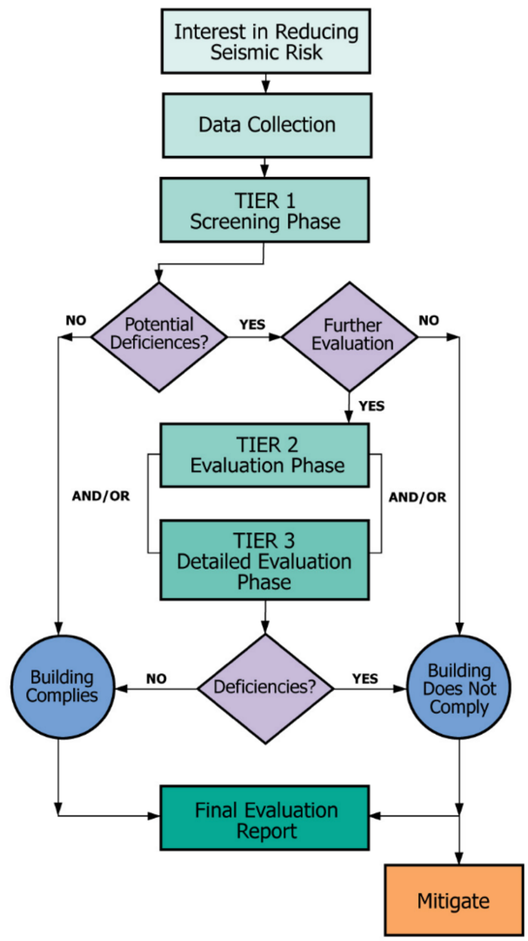

Figure 2-1. Flow Chart and Description of ASCE 41 Seismic Evaluation Procedure.

The Tier 1 checklists in ASCE 41 are specific to each common building type and contain seismic evaluation statements based on observed structural damage in past earthquakes. These checklists screen for potential seismic deficiencies by examining the lateral-force-resisting systems and details of construction that have historically caused poor seismic performance in similar buildings. Tier 1 screenings include basic "Quick Check" analyses for primary components of the lateral system. Tier 1 screenings also include prescriptive checks for proper seismic detailing of connections, diaphragm spans and continuity, and overall system configuration.

Tier 2 evaluations then follow with more-detailed structural and seismic calculations and assessments to either confirm the potential deficiencies identified in the Tier 1 review or demonstrate their adequacy. A Tier 3 evaluation involves an even more detailed analysis and advanced structural and seismic computations to review each structural component's seismic demand and capacity. A Tier 3 evaluation is similar in scope and complexity to the types of analyses often required to design a new building in accordance with the International Building Code (IBC), with a comprehensive analysis aimed at evaluating each component's seismic performance. Generally, Tier 3 evaluations are not practical for typical and regular-type buildings due to the rigorous and complicated calculations and procedures. As indicated in the Scope of Services, this evaluation included a Tier 1 screening of the structural systems.

2.2 Seismic Evaluation and Retrofit Criteria

Performance-Based Earthquake Engineering (PBEE) can be defined as the engineering of a structure to resist different levels of earthquake demand in order to meet the needs and performance objectives of building owners and other stakeholders. ASCE 41 employs a PBEE design methodology that allows building owners, design professionals, and the local building code authorities to establish seismic hazard levels and performance goals for individual buildings.

2.2.1 Site Class Definition

The building site class definition quantifies the site soil's propensity to amplify or attenuate earthquake ground motion propagating from underlying rock. Site class has a direct impact on the seismic design forces utilized to design and evaluate a structure. There are six distinct site classes defined in ASCE 7-16, Site Class A through Site Class F, that range from hard rock to soils that fail such as liquefiable soils. Buildings located on soft or loose soils will typically sustain more damage than similar buildings located on stiff soils or rock, all other things being equal. The Washington State Department of Natural Resources measured the time-averaged shear-wave velocity at each site to 30 meters (100 feet) below the ground surface, Vs30. This measured shear-wave velocity was used to determine the site class. The site class for this building was determined to be **Site Class E**.

2.2.2 Central Elementary School Seismicity

Seismic hazards for the United States have been quantified by the United States Geological Survey (USGS). The information has been used to create seismic hazard maps, which are currently used in building codes to determine the design-level earthquake magnitudes for building design.

The Level of Seismicity is categorized as Very Low, Low, Moderate, or High based on the probabilistic ground accelerations. Ground accelerations and mass generate inertial (seismic) forces within a building (Force = mass x acceleration). Ground acceleration therefore is the parameter that classifies the level of seismicity. From geographic region to region, as the ground accelerations increase, so does the level of seismicity (from low to high). Where this building is located, the design short-period spectral acceleration, S_{DS}, is 1.326 g, and the design 1-second period spectral acceleration, S_{D1}, is 1.98 g. Based on ASCE 41 Table 2-4, the Level of Seismicity for this building is classified as **High**.

The ASCE 41 Basic Performance Objective for Existing Buildings (BPOE) makes use of the Basic Safety Earthquake – 1E (BSE-1E) seismic hazard level and the Basic Safety Earthquake – 2E (BSE-2E). The BSE-1E earthquake is defined by ASCE 41 as the probabilistic ground motion with a 20 percent probability of exceedance in 50 years, or otherwise characterized as a ground motion acceleration with a probabilistic 225-year return period. The BSE-2E earthquake is defined by ASCE 41 as the probabilistic ground motion with a 5 percent probability of exceedance in 50 years, or otherwise characterized as a ground motion acceleration with a probabilistic 975-year return period. The BSE-2N seismic hazard level is the Maximum Considered Earthquake (MCE) ground motion used in current codes for the design of new buildings and is also used in ASCE 41 to classify the Level of Seismicity for a building. The BSE-2N has a statistical ground motion acceleration with 2 percent probability of exceedance in 50 years, or otherwise characterized as a ground motion acceleration with a probabilistic 2,475-year return period.

Table 2.2.1-1 provides the spectral accelerations for the 225-year, 975-year, and 2,475-year return interval events specific to Central Elementary School that are considered in this study.

Table 2.2.1-1. Spectral Acceleration Parameters (Site Class E).

BSE-1E 20%/50 (225-year) Event		BSE-1N 2/3 of 2,475-year Event		BSE-2E 5%/50 (975-year) Event		BSE-2N 2%/50 (2,475-year) Event	
0.2 Seconds	0.79 g	0.2 Seconds	1.326 g	0.2 Seconds	1.418 g	0.2 Seconds	1.989 g
1.0 Seconds	0.508 g	1.0 Seconds	1.98 g	1.0 Seconds	1.963 g	1.0 Seconds	2.97 g

2.2.3 Central Elementary School Structural Performance Objective

The school building is an Educational Group E occupancy (Risk Category III) structure and has not been identified as a critical structure requiring immediate use following an earthquake. However, Risk Category III buildings are structures that represent a substantial hazard to human life in the event of failure. According to ASCE 41, the BPOE for Risk Category III structures is the Damage Control structural performance level at the BSE-1E seismic hazard level and the Limited Safety structural performance level at the BSE-2E seismic hazard level. The ASCE 41 Tier 1 evaluations were conducted in accordance with ASCE 41 requirements and ASCE 41 seismic performance levels. Concept-level upgrades were developed for the **Life Safety** structural performance level at the **BSE-1N** seismic hazard level in accordance with DNR direction, the project scope of work, and the project legislative language.

At the Life-Safety performance level, the building may sustain damage while still protecting occupants from life-threatening injuries and allowing occupants to exit the building. Structural and nonstructural components may be extensively damaged, but some margin against the onset of partial or total collapse remains. Injuries to occupants or persons in the immediate vicinity may occur during an earthquake; however, the overall risk of life-threatening injury as a result of structural damage is anticipated to be low. Repairs may be required before reoccupying the building, and, in some cases, repairs may be economically unfeasible.

Knowledge Factor

A knowledge factor, *k*, is an ASCE 41 prescribed factor that is used to account for uncertainty in the as-built data considering the selected Performance Objective and data collection processes (availability of existing drawings, visual observation, and level of materials testing). No in-situ testing of building materials was performed; however, some material properties and existing construction information were provided in the existing record drawings. If the concept design is developed further, additional materials tests and site investigations will be required to substantiate assumptions about the existing framing systems.

ASCE 41 Classified Building Type

Use of ASCE 41 for seismic evaluations requires buildings to be classified from a group of common building types historically defined in previous seismic evaluation standards (ATC-14, FEMA 310, and ASCE 31-03). For this evaluation, the school is classified in ASCE 41 Table 3-1 as a concrete shear wall building with stiff diaphragms, **C2**. Concrete shear wall buildings (C2) include buildings that have floor and roof framing that consists of cast-in-place concrete slabs, concrete beams, one-way joists, two-way waffle joists, or flat slabs. Seismic forces are resisted by cast-in-place concrete shear walls. The two flat-roof portions of the structure, i.e., at the north classroom and east gymnasium wings, have wood-framed flexible roof diaphragms. It is unclear if these portions of the facility have concrete shear walls or use a different material such as reinforced masonry or wood framing. Further investigation is recommended.

2.3 Report Limitations

The professional services described in this report were performed based on available record drawing information and limited visual observation of the structure. No other warranty is made as to the professional advice included in this report. This report provides an overview of the seismic evaluation results and does not address programming and planning issues. This report has been prepared for the exclusive use of DNR/WGS and is not intended for use by other parties, as it may not contain sufficient information for purposes of other parties or their uses.

3.0 Building Description & Seismic Evaluation Findings

3.1 Building Overview

3.1.1 Building Description

Original Year Built: 1952-1953
Building Code: 1949 UBC

Number of Stories: 1
Floor Area: 38,946 SF

FEMA Building Type: C2
ASCE 41 Level of Seismicity: High
Site Class: E

Central Elementary is a single-story building constructed in 1952. The core of the building appears to be a cast-in-place concrete structure with concrete sawtooth roof. There is a rectangular, wood-framed, flat-roof classroom wing at the north end of the facility. At the east end of the facility there is another rectangular-footprint, wood-framed, flat-roofed wing housing the gymnasium and kitchen spaces. The total footprint area is a cross between a "C" shape and a rectangle, with an approximate gross area of 39,000 square feet. The typical roof height appears to be about 15 feet, although there are several roof planes, especially at the gymnasium. According to a 2009 Study and Survey provided by OSPI, a modernization in 2000 included infill plywood shear walls and anchorage of concrete walls to the roof structure. However, existing original 1952 drawings and 2000 modernization drawings were not available, and it is unclear what structural work was performed in the 2000 modernization and if any structural retrofits were made at that time.

3.1.2 Building Use

This building is used as an elementary school. There are about 12 classrooms, a special education classroom, a music class, library, large gymnasium, commons area with full-service kitchen, several storage or supply rooms, and an administrate area with several offices and a staff lounge.

3.1.3 Structural System

Table 3.1.3-1. Structural System Descriptions.

Structural System	Description
Structural Roof	Based solely on observations during the site visit, there appear to be two roof structural systems used. The sawtooth roof structure appears to be a

Table 3.1.3-1. Structural System Descriptions.

Structural System	Description
	cast-in-place concrete system of one-way slabs spanning between concrete beams that are parallel to the sawtooth slope direction. The roof at the north classroom wing is not visible but is believed to be a wood-framed low-slope roof. The roofs at the east gymnasium, commons, and kitchen area are low-slope wood-framed roofs. These wood framed roofs have straight-sheathed wood planks supported on timber beams. The gymnasium roof has large timber trusses supporting a multi-plane roof.
Structural Floor(s)	The building is a single story, which appears to have a slab on grade, thus no elevated structural floors.
Foundations	Existing drawings are not available; therefore, the foundation system could not be reviewed. However, information from a 2009 Study and Survey indicates that the foundations consist of timber piling and concrete foundations. Soils are believed to be poor in this area and potentially susceptible to liquefaction.
Gravity System	The gravity system at the sawtooth roof structure appears to be a concrete one-way roof slab that is supported by concrete beams that frame parallel to the sawtooth slope. It appears that the exterior walls are designed as spandrels over the windows, delivering gravity loads to the narrow concrete piers between openings. A majority of the roof gravity load, therefore, transfers to the pony walls, which have alternating openings. A support frame is visible in the library, which suggests that the pony walls might be concrete post-and-beam framing rather than bearing walls. Gravity loads at the flat-roof portions are believed to be resisted by bearing walls. It is unclear if the brick masonry is simply a veneer or if it is structural. The structure was not accessible for visual verification during the site visit.
Lateral System	There are two roof diaphragm types encountered: concrete slab and straight-sheathed wood-framed roofs. Concrete slabs distribute lateral load to shear walls or frames based on rigid body mechanics. The wood-framed diaphragms are flexible and distribute load to vertical shear resisting elements by tributary area. At the flat roof structure, there seems to be a lot of wall length uninterrupted by fenestration, which might act as shear walls. At the sawtooth roof structure, it appears that only the short piers between windows can resist shear.

3.1.4 Structural System Visual Condition

Table 3.1.4-1. Structural System Condition Descriptions.

Structural System	Description
Structural Roof	No visible signs of damage or deterioration.
Foundations	Foundation elements were not visible.
Gravity System	Minor cracking at concrete and masonry at the exterior walls.
Lateral System	Minor cracking at concrete and masonry at the exterior walls.

3.2 Seismic Evaluation Findings

3.2.1 Structural Seismic Deficiencies

The structural seismic deficiencies identified during the Tier 1 evaluation are summarized below. Commentary for each deficiency is provided based on this evaluation.

Table 3.2.1-1. Identified Structural Seismic Deficiencies Based on Tier 1 Checklists.

Deficiency	Description
Overturning	The narrow piers at the long walls of the sawtooth roof structure are shorter than the 8'-9" calculated minimum length for compliance.
Shear Stress Check	The narrow concrete piers at the longitudinal walls of the sawtooth roof structure appear to be overstressed.
Spans	The gymnasium roof appears to be straight sheathed and the spans between lateral-force-resisting elements exceed 24 feet. The underside of a straight-sheathed roof is also visible in the mechanical room. The locations of shear walls at the north wing are unknown, but assuming no interior shear walls, that area is also not compliant.

3.2.2 Structural Checklist Items Marked as "U"nknown

Where building structural component seismic adequacy was unknown due to lack of available information or limited observation, the structural checklist items were marked as "unknown". These items require further investigation if definitive determination of compliance or noncompliance is desired. The unknown structural checklist items identified during the Tier 1 evaluation are summarized below. Commentary for each unknown item is provided based on the evaluation.

Table 3.2.2-1. Identified Structural Checklist Items Marked as Unknown.

Deficiency	Description
Load Path	Could not verify, as drawings were not available during this review and the load path is generally hidden by finishes, etc. From what could be observed on site, it does appear to have a complete load path; however, further investigation for verification is recommended.
Torsion	The sawtooth roof is believed to be concrete, thus rigid, and subject to torsional consideration. The remaining roofs appear to be flexible wood roofs, which are not subject to torsional irregularities. There is insufficient existing information to perform a detailed analysis; however, due the distribution of wall openings at the sawtooth concrete structure, it appears that there is a potential eccentricity between the centers of mass and rigidity that would result in torsional irregularity. Further investigation is recommended, including a site survey to develop an analytical model to verify if a torsional irregularity exists.
Liquefaction	The ICOS system identifies this site as having moderate to high liquefaction potential. Further investigation by a licensed geotechnical engineer is necessary to verify liquefaction potential.
Surface Fault Rupture	There does not appear to be a record of surface faulting in this region; however, investigation by a licensed geotechnical engineer is necessary to verify the surface fault rupture potential.
Ties Between Foundation Elements	Original structural drawings were not found, and connections between foundation elements could not be visually verified during the site visit.
Complete Frames	The pony walls at the library are supported by a frame; however, the details at the exterior walls could not be verified. There is no sign of a pilaster, so the column must be integrated into the wall. Further investigation is recommended.
Reinforcing Steel	No existing information was available.
Wall Anchorage at Flexible Diaphragms	No existing information was available; any existing connections could not be visually verified during the site visit.
Transfer to Shear Walls	No existing information was available.
Foundation Dowels	No existing information was available.
Deflection Compatibility	The columns that support the pony walls at the sawtooth walls are of particular concern and may require further investigation using a rebar scanner or other means to verify the spacing of secondary reinforcement.

Table 3.2.2-1. Identified Structural Checklist Items Marked as Unknown.

Deficiency	Description
Coupling Beams	The pony walls at the library are supported by a frame; however, the details at the exterior walls could not be verified. There is no sign of a pilaster, so the column must be integrated into the wall. Further investigation is recommended.
Uplift at Pile Caps	The foundation type is not known, but due to the heavy structure and what are believed to be poor soils, it is possible piles were used. Connection details were not found, as original drawings were not available. Further investigation is recommended.

3.2.3 Nonstructural Seismic Deficiencies

Table 3.2.3-1 summarizes the seismic deficiencies in the nonstructural systems. The Tier 1 screening checklists are provided in Appendix A.

Table 3.2.3-1. Identified Nonstructural Seismic Deficiencies based on Tier 1 Checklists.

Deficiency	Description
CF-2 Tall Narrow Contents	Tall narrow contents, such as tall bookshelves, should be anchored or braced.
CF-3 Fall-Prone Contents	Heavy equipment higher than 4 feet above the floor should be braced or restrained.

3.2.4 Nonstructural Checklist Items Marked as "U"nknown

Where building nonstructural component seismic adequacy was unknown due to lack of available information or limited observation, the nonstructural checklist items were marked as "unknown". These items require further investigation if definitive determination of compliance or noncompliance is desired. The unknown nonstructural checklist items identified during the Tier 1 evaluation are summarized below. Commentary for each unknown item is provided based on the evaluation.

Some nonstructural deficiencies may be able to be mitigated by school district staff. Other nonstructural components that require substantial mitigation may be more appropriately included in a long-term mitigation strategy. Some typical conceptual details for the seismic upgrade of nonstructural components can be found in the FEMA E-74 Excerpts appendix.

Table 3.2.4-1. Identified Nonstructural Checklist Items Marked as Unknown.

Deficiency	Description
LSS-1 Fire Suppression Piping; and LSS-2 Flexible Couplings	All spaces except the gymnasium appear to have fire suppression piping; however, bracing was not observed. Couplings were not observed. Recommend a licensed fire protection engineer review to verify.
M-1 Ties; M-3 Weakened Planes; M-4 Unreinforced Masonry Backup; and M-6 Anchorage	As-built information was not available at the time of this evaluation, so masonry veneer ties, connections at weakened planes, presence of any unreinforced masonry backup, and anchorage details could not be verified. Further investigation is recommended, especially in areas where failures of the masonry veneer could result in a fall hazard or block paths of egress.
ME-3 Tall Narrow Equipment	Bracing or anchorage of tall narrow electrical panels in the mechanical/electrical room could not be verified. They should be braced or anchored.

4.0 Recommendations and Considerations

4.1 Seismic-Structural Upgrade Recommendations

Concept-level seismic upgrade recommendations to improve the lateral-force-resisting system were developed. The sketches in Appendix B depict the concept-level structural upgrade recommendations outlined in this section. The following concept recommendations are intended to address the structural deficiencies noted in Table 3.2.1-1. This concept-level seismic upgrade design represents just one of several alternative seismic upgrade design solutions and is based on preliminary seismic evaluation and analysis results. Final analysis and design for seismic upgrades must include a more detailed seismic evaluation of the building in its present or future configuration. Proposed seismic upgrades include the following.

4.1.1 Additional Shear Walls and Strongbacking at Existing Walls

The longitudinal walls of the concrete sawtooth roof structure have a significant length of window openings. This leaves a small quantity of narrow piers that will be overstressed. Additional shear wall length will be achieved by infilling several existing openings and by strongbacking the existing wall to create longer piers. Reinforcement of the new concrete piers should be doweled into existing concrete elements to achieve composite capacity.

4.1.2 Install New Foundations at New Shear Walls Under Existing Foundations

Where the concrete shear wall piers will be extended by adding new wall, additional footings must be installed to resist overturning forces. The soil is believed to be poor and susceptible to liquefaction. It is recommended that a pile cap with pin piles be installed under the existing concrete foundation. Reinforcement at the boundary elements should be drilled through the existing foundation to be anchored in the new pile caps.

4.1.3 Soil Treatment to Mitigate Liquefaction Hazard

The liquefaction hazard is believed to be moderate to high at this site. The existing foundation system, constructed in the 1950s, is unknown. To mitigate liquefaction-induced subsidence of the structure, anti-liquefaction soil treatment such as jet grouting at the new foundations should be considered. A geotechnical engineer would need to evaluate options and provide recommendations. For the purposes of this concept study, it is assumed that the soil down to approximately 30 feet below grade at the new pile cap locations will need to be improved.

4.1.4 New Diaphragm Anchors and Roof Sheathing at Flat Roofs

The flat roofs at the north classroom wing and east cafeteria and gymnasium wing are straight-sheath wood-framed diaphragms. The existing diaphragm spans exceed the maximum permitted for straight sheathing. Structural wood panel sheathing should be installed over the straight sheathing to mitigate this noncompliance. The existing straight sheathing planks can act as blocking at the structural wood panel edges, which will provide additional strengthening.

The existing shear wall locations and construction, e.g. wood, CMU, or concrete, are not known. Further investigation is needed to confirm. It is assumed that the walls are cementitious, i.e., concrete or CMU, and as such must be anchored to the roof diaphragms. Tension ties such as Simpson LTT should be installed. Although the roof framing configuration is not known, for this concept study, a strap at 48 inches on center around the perimeter of the flat-roof structures will be assumed. The out-of-plane anchorage enhancements can be performed as part of a future re-roofing project to take advantage of the access provided to the top of the existing plywood roof sheathing for the nailing to the blocking and strapping required.

4.2 Foundations and Geotechnical Considerations

A detailed geotechnical analysis of the site soils was not included in the scope of this study. As a result, the geotechnical seismic effects on the existing building and its foundations, such as the presence of liquefiable soils, allowable soil bearing pressures, and pile capacities are unknown at this time. However, based on state of Washingtonliquefaction mapping, this building is located on soils classified with a moderate to high susceptibility of liquefaction.

Liquefaction is the tendency of certain soils to saturate and lose strength during strong earthquake shaking, causing it to flow and deform similar to a liquid. Liquefaction, when it occurs, drastically decreases the soil bearing capacity and tends to lead to large differential settlement of soil across a building's footprint. Liquefaction can also cause soils to spread laterally and can dramatically affect a building's response to earthquake motions, all of which can significantly compromise the overall stability of the building and possibly lead to isolated or widespread collapse in extreme cases. Existing foundations damaged as a result of liquefiable soils also make the building much more difficult to repair after an earthquake.

Buildings that are not founded on a raft foundation or deep foundation system (such as grade beams and piles), and those with conventional strip footings and isolated spread footings that are not interconnected well with tie beams, are especially vulnerable to liquefiable soils. Mitigation techniques used to improve structures in liquefiable soils vary based on the type and amount of liquefiable soils and may include ground improvements to densify the soil (aggregate piers, compaction piling, jet grouting), installation of deep foundations (pin piling, augercast piling, micro-piling), and installation of tie beams between existing footings.

Based on a 2009 Study and Survey provided by OSPI, the foundations of Central Elementary School consist of wood piling and concrete foundations; however, this could not be confirmed due to existing drawings not being available. It is recommended that a detailed geotechnical study and investigation be completed on the building site to determine the nature of the liquefaction hazard and the characteristics of the site soils. It is also recommended that additional investigation and records research be done to determine the existing foundations for this building. Foundation mitigation and ground improvement is likely required, and the recommended geotechnical investigation could have a major impact on the scope of work required for seismic retrofit.

4.3 Tsunami Considerations

Tsunami analysis was outside the scope of this project. However, based on Washington State Department of Natural Resources tsunami inundation mapping, the location of the building is within the expected tsunami inundation zone for a Cascadia Subduction Zone earthquake. While there is significant uncertainty surrounding tsunami inundation heights, the mapping indicates that there is a likelihood of tsunami inundation at the building location.

It may be worthwhile to conduct a detailed tsunami study prior to performing building seismic upgrades. Since tsunamis can cause significant infrastructure damage and also pose a significant risk to life safety, it can often be more cost effective to build a new school outside of the tsunami inundation zone rather than seismically upgrade the existing building. Alternatively, seismically upgrading the facility could allow occupants to safely evacuate and reach locations away from the tsunami inundation zone. Construction of a tsunami vertical evacuation structure may be another alternative to provide safe refuge from a tsunami. In any case, it is recommended that a detailed tsunami evacuation plan be used that gives people a high likelihood of successfully escaping a tsunami regardless of whether the plan is to reach higher ground or take refuge in a vertical evacuation structure. A detailed tsunami study could comparatively evaluate different options and provide recommendations on appropriate actions to take.

4.4 Nonstructural Recommendations and Considerations

Table 3.2.3-1 identifies nonstructural deficiencies that do not meet the performance objective selected for Central Elementary School. It is recommended that these deficiencies be addressed to provide nonstructural performance consistent with the performance of the upgraded structural lateral-force-resisting system. As-built information for the existing nonstructural systems, such as fire sprinklers, mechanical ductworks, and piping, are not available for review. Only limited visual observation of the systems was performed during field investigation due to limited access or visibility to observe existing conditions. The conceptual mitigation strategies provided in this study are preliminary only. The final analysis and design for seismic rehabilitation should include a detailed field investigation.

4.4.1 Architectural Systems

This section addresses existing construction that, while not posing specific hazards during a seismic event, would be affected by the seismic improvements proposed.

For any remodel project of an existing building, the International Existing Building Code (IEBC) would be applicable. The intent of the IEBC is to provide flexibility to permit the use of alternative approaches to achieve compliance with minimum requirements to safeguard the public health, safety, and welfare insofar as they are affected by the work being done.

Energy Code

Elements of the exterior building envelope to be affected by the proposed seismic upgrade work may be required to be brought up to the current Washington State Energy Code per Chapter 5, where applicable.

Accessibility

It should also be noted that, as a part of any upgrade to existing buildings, the IEBC will require that any altered primary function spaces (classrooms, gyms, entrances, offices) and routes to these spaces, be made accessible to the current accessibility standards of the Americans with Disabilities Act (ADA), unless technically infeasible.

This would include but is not limited to accessible restrooms, paths of travel, entrances and exits, parking, signage and Life Safety alarm systems. Under no circumstances should the facility be made less accessible. The IEBC does, however, have exceptions for areas that do not contain a primary function (storage room, utility rooms) and states that costs of providing the accessible route are not required to exceed 20 percent of the costs of the alterations affecting the area of Primary Function.

As with any major renovation and modernization, an ADA study should be performed to determine the extent to which an existing facility would need to be improved in order to be in compliance with the ADA.

Hazardous Materials Survey

Given the age of the building, existing construction elements such as floor tile and/or adhesive, pipe insulation, etc. could contain asbestos. A Hazardous Materials survey of the building should be performed prior to the start of any demolition work.

Additional Shear Walls and Strongbacking at Existing Exterior Walls

The existing suspended acoustical tile ceiling may need to be removed for access to interior side of masonry at the new strongback walls and anchors. It may be difficult to match the existing acoustic ceiling tiles that are currently installed. Given the age and condition of the tiles, it may be advisable to replace all existing classroom ceiling tiles as a part of an overall modernization project. Upgrade wall insulation to meet current E code requirements.

Rooms in which windows and/or openings in the exterior wall are reduced with infilling must be reevaluated to ensure current light and ventilation requirements are met.

New Foundations at New Shear Walls Under Existing Foundations

New shear wall strongback backing will require removal of and infill at some existing openings. Interior wall finishes at infill to match adjacent wall finishes. Floor and ceiling finishes may be affected. Wall thermal and moisture barriers must be upgraded to current code requirements.

Existing electrical outlets, switches, and other items may be impacted by this work. Paint and new rubber base may be installed to match adjacent wall finishes.

New Diaphragm Anchors and Roof Sheathing at Flat Roofs

A portion of the existing suspended acoustical tile ceiling may need to be removed for access to masonry at the new strongback walls and anchors. It may be difficult to match the existing acoustic ceiling tiles that are currently installed, suggest replacing ceiling tiles.

Given the extent of new roof sheathing, this work would best be done in conjunction with a building reroof. As part of a reroof project, we recommend installing an above-roof continuous rigid insulation of R-38 over the entire roof to comply with current energy code. Any mechanical equipment curbs should be raised to accommodate the thicker insulation. Alternately, additional batt insulation above the ceilings at the bottom of the trusses would need to be added to increase the existing R-13 insulation to an R-49.

Ceiling in Paths of Egress

The suspended ceiling in the main corridor is an integrated acoustical ceiling system, likely with a suspended metal T-grid. Because this corridor is a main path of egress, it is recommended that the ceiling grid support system be further investigated and checked for proper seismic bracing and compression support for every 12 square feet of area and proper edge clearance detailing at the corridor walls. Preventing the risk of a fallen integrated ceiling system will mitigate the risk of obstructions impeding the paths of egress as students and faculty evacuate the building following a seismic event.

Lighting Fixtures in Paths of Egress

The light fixtures observed in the main corridor are supported within an integrated ceiling system that is over a main path of egress. Maintenance and facility staff should verify that each fixture is independently supported to the roof structure from opposite corners and add wire supports as necessary.

Contents and Furnishings

Buildings often contain various tall and narrow furniture, such as shelving and storage units, that are freestanding away from any backing walls. High book shelving in the library, for example, can be highly susceptible to toppling if not anchored properly to the backing walls or to each other, and can become a life safety hazard. It is recommended that maintenance and facility staff verify that the tops of the shelving units are braced or anchored to the nearest backing wall or provide overturning base restraint. Heavy items weighing more than 20 pounds on upper shelves or cabinet furniture should also be restrained by netting or cabling to avoid becoming falling hazards to students or faculty below.

4.4.2 Mechanical Systems

The main seismic concerns for mechanical equipment are sliding, swinging, and overturning. Inadequate lateral restraint or anchorage can shift equipment off its supports, topple equipment to the ground, or dislodge overhead equipment, making them falling hazards. Investigation of above-ceiling mechanical equipment and systems was not part of this study, but an initial investigation for the presence of mechanical equipment bracing can be performed by maintenance and facility staff to see if equipment weighing more than 20 pounds with a center of mass more than 4 feet above the adjacent floor level is laterally braced. If bracing is not present, and the equipment poses a falling hazard to students and faculty below, further investigation is recommended by a structural engineer.

4.5 Opinion of Probable Conceptual Seismic Upgrades Costs

An opinion of probable project costs of the concept-level seismic upgrade recommendations provided in this report is included in Appendix C. The input of the scope of work to develop the probable costs is the Tier 1 checklists and the preliminary concept-level seismic upgrades design recommendations and sketches. These preliminary concept-level design sketches depict a design concept that could be implemented to improve the seismic safety of the building structure. It is important to note the preliminary seismic upgrades design concept is based on the results of the Tier 1 seismic screening checklists and engineering design judgement and has not been substantiated by detailed structural analyses and calculations.

For this preliminary opinion of probable costs, the estimate of construction costs of the preliminary scope of work is developed based on current 1st Quarter (1Q) 2021 costs. Costs are then escalated to 4Q 2022 at 6% per year of the baseline cost estimate. Costs are developed based on the Tier 1 checklist, concept-level seismic upgrade design sketches, and project narratives.

A range of the cost estimate of -20% (low) to +50% (high) is used to develop the range of the construction cost estimate for the concept-level scope of work. The -20% to +50% range guidance is from Table 1 of the AACE International Recommended Practice 56R-08, *Cost Estimate Classification System*. This estimate is classified as a Class 5 based on the level of design of 0% to 2%. The range of a Class 5 construction cost estimate based on the AACE guidance selected for this estimate is a -20% to +50%.

The estimated total cost (construction costs plus soft costs) to mitigate the deficiencies identified in the Tier 1 checklists of the Central Elementary School Main Building ranges between approximately $4.27M and $8.0M (-20%/+50%). The baseline estimated total cost to seismically upgrade this building is approximately $5.34M. On a per-square-foot basis, the baseline seismic upgrade cost is estimated to be approximately $137 per square foot in 4Q 2022 dollars, with a range between $110 per square foot and $205 per square foot.

4.5.1 Opinion of Probable Construction Costs

This conceptual opinion of construction cost includes labor, materials, equipment, and scope contingency, general contractor general conditions, home office overhead, and profit. This is based on a public sector design-bid-build project delivery method. Project delivery methods such as negotiated, state of Washington GC/CM, and design-build are not the basis of the construction costs. Owner's soft costs are described below in section 4.5.2.

The cost is developed in 1Q 2021 costs. The costs are then escalated to 4Q 2022 using an escalation rate of 6.0% per year. If the mid-point of construction will occur at a date earlier or later than 4Q 2022, then it is appropriate to adjust the escalation to the revised mid-point of construction. Construction costs excluded from the estimate are site work, phasing of construction, additional building modifications not directly related to the seismic scope of work, off hours labor costs, accelerated schedule overtime labor costs, replacement/relocation/additional FF+E, and building code changes that occur after this report.

For project budget planning purposes, it is highly recommended that the opinion of probable project costs is determined including: the overall construction budget of the seismic upgrade and additional scope of work for the building via the services of an A/E design team to study the proposed seismic mitigation strategies to refine the concept-level seismic upgrades design approach contained in this report, determine the construction timeline to adjust the escalation costs, define the construction phasing, if any, and the project soft costs.

4.5.2 Opinion of Probable A-E Design Budgets and Owner's Additional Project Costs (Soft Costs)

Additional owner's project costs would likely include owner's project administration costs, including project management, financing/bond costs, administration/contract/accounting costs, review of plans, value engineering studies, building permits, bidding costs, equipment, fixtures, furnishings and technology, and relocation of the school staff and students during construction. These costs are known as soft costs.

These soft costs have been included in the opinion of probable costs at 40% of the baseline probable construction cost for the seismic upgrade of this building.
The Soft Costs used for the projects that total to 40% are:
A+E Design - 10%
QA/QC Testing - 2%
Project Administration - 2%
Owner Contingency - 11%
Average Washington State Sales Tax - 9%
Building Permits - 6%

It is typical for soft costs to vary from owner to owner. Based upon our team members' experience on K-12 school projects in the state of Washington, it is our opinion that an allowance of 40% of the average probable construction cost is a reasonable and appropriate soft cost recommendation for planning purposes. We also recommend that each owner develop their own soft costs as part of their budgeting process and not rely solely on this recommended percentage.

4.5.3 Opinion of Escalation Rate

A 6.0%/year construction cost escalation rate is used for planning purposes for the conceptual estimates. The rate is compounded annually to the projected midpoint of construction. This rate is representative of the escalation based on the previous five years of market experience of construction costs throughout the state of Washington and is projected going forward for these projects. This rate is calculated to the 4th Quarter of 2022 as an allowance for planning purposes. The actual construction schedule for the project is to be determined and we recommend the escalation cost be revised based on revised construction schedule using the 6%/year rate.

Table 4.5.3-1. Seismic Upgrades Opinion of Probable Construction Costs.

Building	FEMA Bldg Type	ASCE 41 Level of Seismicity / Site Class	Structural Performance Objective	Bldg Gross Area	Estimated Seismic Upgrade Cost Range $/SF (Total)	Estimated Seismic Upgrade Cost/SF (Total)
Central Elementary School Main Bldg	C2	High / D	**Structural**			
			Life Safety	38,946 SF	$60 ($2.35M) - $113 ($4.40M)	$75 ($2.93M)
			Nonstructural			
			Life Safety	38,946 SF	$18 ($704K) - $34 ($1.32M)	$23 ($880K)
			Total			
				38,946 SF	$78 ($3.05M) - $147 ($5.72M)	$98 ($3.81M)
					Estimated Soft Costs:	$1.53M
					Total Estimated Project Costs:	**$5.34M**

W: Wood-Framed; URM: Unreinforced Masonry; RM: Reinforced Masonry; C: Reinforced Concrete; PC: Precast concrete; S: Steel-framed

Appendix A: ASCE 41 Tier 1 Screening Report

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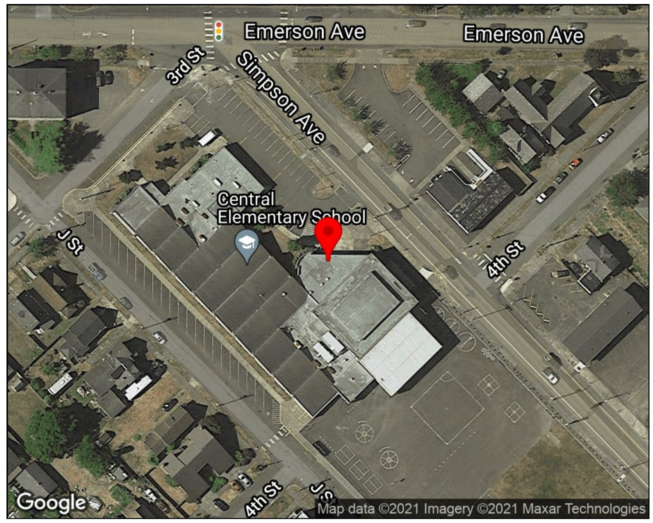
1. Hoquiam, Central Elementary School, Main Building

1.1 Building Description

Building Name:	Main Building
Facility Name:	Central Elementary School
District Name:	Hoquiam
ICOS Latitude:	46.9803
ICOS Longitude:	-123.889045
ICOS Building ID:	58356
ASCE 41 Bldg Type:	C2
Enrollment:	239
Gross Sq. Ft. :	38946
Year Built:	1952
Number of Stories:	1
$S_{XS\ BSE\text{-}2E}$:	1.418
$S_{X1\ BSE\text{-}2E}$:	1.963
ASCE 41 Level of Seismicity:	High
Site Class:	E
V_{S30}(m/s):	168
Liquefaction Potential:	Moderate to High
Tsunami Risk:	Yes
Structural Drawings Available:	No
Evaluating Firm:	WSP

** Liquification Potential and Tsunami Risk is based on publicly available state geologic hazard mapping.*



Central Elementary is a single story building, constructed in 1952. The core of the building appears to be a cast-in-place concrete structure with concrete sawtooth roof. There is a rectangular, wood-framed, flat-roof classroom wing at the north end of the facility. At the east end of the facility there is another rectangular footprint wood-framed, flat roofed wing housing the gymnasium and kitchen spaces. The total footprint area is a cross between a "C" shape and a rectangle, with an approximate gross area of 39,000 square feet. The typical roof height appears to be about 15 feet, although there are several roof planes, especially at the gymnasium. Apparently there was a modernization in 2000, however it is unclear if any structural retrofits were made at that time.

1.1.1 Building Use

This building is used as an Elementary School. There are about 12 classrooms, a special education class room, a music class, library, large gymnasium, commons area with full service kitchen, several storage or supply rooms, and an administrate area with several offices and a staff lounge.

1.1.2 Structural System

Table 1-1. Structural System Description of Central Elementary School

Structural System	Description
Structural Roof	Based solely on observations during the site visit, there appear to be two roof structural systems used. The sawtooth roof structure appears to be a cast-in-place concrete system of one-way slabs spanning between concrete beams which are parallel to the sawtooth slope direction. The roofs at the north classroom wing is not visible, but is believed to be a wood-framed low slope roof. The roofs at the east gym, commons and kitchen area are low slope wood framed roofs. These wood framed roofs have straight sheathed wood planks, supported on timber beams. The gym roof has large timber trusses supporting a multi-plane roof.
Structural Floor(s)	The building is a single story, which appears to have a slab-on-grade, thus no elevated structural floors.
Foundations	The foundation system is unknown. Soils are believed to be poor in this area and potentially susceptible to liquefaction. Given the amount of concrete used at the sawtooth roof structure, it is possible that some sort of pile foundation was used. Similarly, perhaps at the gymnasium there are piles supporting the columns that support the large roof trusses. The rest of the building possibly has a traditional concrete spread footing system. The first floor is a non-structural concrete slab on grade.
Gravity System	The gravity system at the sawtooth roof structure appears to be a concrete one-way roof slab that is supported by concrete beams which frame parallel to the sawtooth slope. It appears that the exterior walls must be designed as spandrels over the windows, delivering gravity loads to the narrow concrete piers between openings. A majority of the roof gravity load, therefore transfers to the pony walls, which have alternating openings. A support frame is visible in the library, which suggests that the pony walls might be concrete post-and-beam framing rather than bearing walls. Gravity loads at the flat-roof portions are believed to be resisted by bearing walls. It is unclear if the brick masonry is simply a veneer or if it is structural. The structure was not accessible for visual verification during the site visit.

Lateral System	There are two roof diaphragms type encountered: concrete slab and straight-sheathed wood framed roofs. Concrete slabs distribute lateral load to shear walls or frames based on rigid body mechanics. The wood framed diaphragms are flexible and distribute load to vertical shear resisting elements by tributary area. At the flat roof structure, there seems to be a lot of wall length uninterrupted by fenestration, which might act as shear walls. At the sawtooth roof building structure, it appear that only the short piers between windows can resist shear in the longitudinal building direction.

1.1.3 Structural System Visual Condition

Table 1-2. Structural System Condition Description of Central Elementary School

Structural System	Description
Structural Roof	No visible signs of damage or deterioration.
Structural Floor(s)	Not applicable.
Foundations	Foundation elements were not visible.
Gravity System	Minor cracking at concrete and masonry at the exterior walls.
Lateral System	Minor cracking at concrete and masonry at the exterior walls.

Figure 1-1. View in the school office.

Figure 1-2. View in the workroom.

Figure 1-3. Panoramic view of the high bay gymnasium.

Figure 1-4. School library and media center.

Figure 1-5. View of Kitchen.

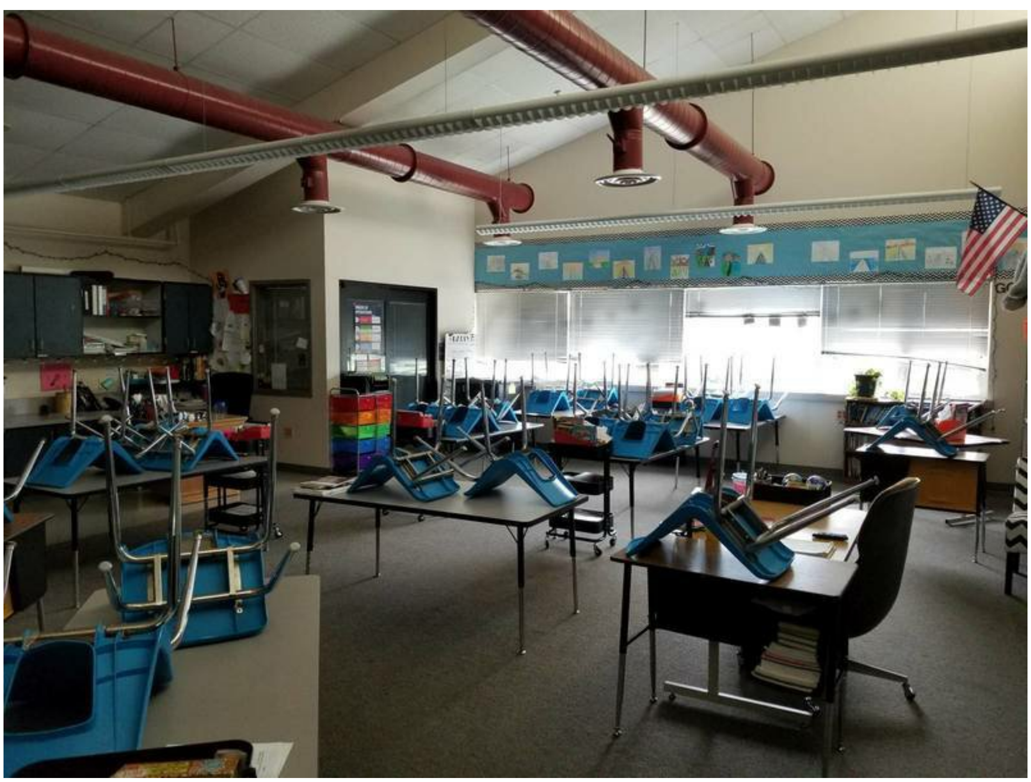


Figure 1-6. View of typical classroom interior.

Figure 1-7. Panoramic view of the original saw-tooth roof classroom wing.

Figure 1-8. Panoramic view of the front entrance and east side of school.

Figure 1-9. Covered play area at the south end of the building.

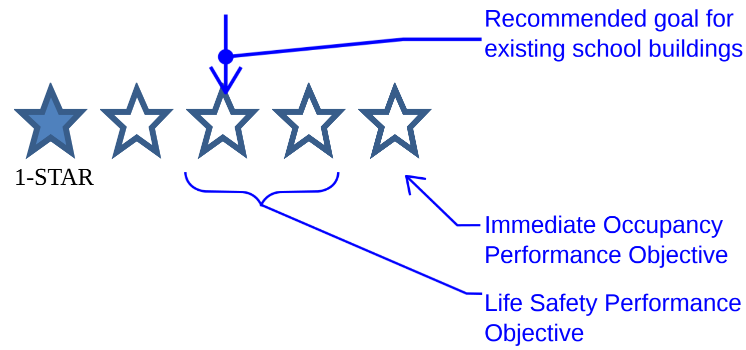
Figure 1-10. View in typical hallway.

1.1.4 Earthquake Performance Rating System - Structural Safety Rating

The seismic evaluation items from the ASCE 41 Tier 1 seismic evaluation checklist have been translated to a Structural Safety star-rating using the *EPRS ASCE 41-13 Translation Procedure*. There are two other safety sub-ratings using the EPRS *Translation Procedure*: a Geologic safety sub-rating and a Nonstructural safety sub-rating, that are not included below.

The structural safety star-rating below is a preliminary rating based on the information available for this study. The geologic checklist items have been excluded from the structural safety star-rating. If a building's structural safety star-rating is to be improved, it may also be necessary to further assess the geologic conditions of the building site. Determining the final star-rating of a building is intended to be an iterative process and preliminary ratings will often times be conservative until more field investigation, structural analysis, and engineering judgment is performed by a structural engineer. The intent in providing a preliminary star-rating as part of this study is to provide school districts with the action lists below to further improve the seismic performance and safety of the buildings that were assessed. The tables below indicate the Unknown (U) or Noncompliant (NC) structural seismic evaluation items that should be mitigated or further investigated to improve the Earthquake Performance Rating System (EPRS) structural safety rating for this building.

EPRS Structural Safety Rating for Central Elementary School, Main Building:



1-STAR	Risk of Collapse in Multiple or Widespread Locations (Expected performance as a whole would lead to multiple or widespread conditions known to be associated with earthquake-related collapse resulting in injury, entrapment, or death.)
2-STAR	Risk of Collapse in Isolated Locations (Expected performance in certain locations within or adjacent to the building would lead to conditions known to be associated with earthquake-related collapse resulting in injury, entrapment, or death.)
3-STAR	Loss of Life Unlikely (Expected performance results in conditions that are unlikely to cause severe structural damage or loss of life). A 3-star rating meets the Tier 1 Life Safety (LS) structural performance objective.
4-STAR	Serious Injuries Unlikely (Expected performance results in conditions that are associated with limited structural damage and are unlikely to cause serious injuries).
5-STAR	Injuries and Entrapment Unlikely (Expected performance results in conditions that are associated with minimal structural damage and are unlikely to cause injuries or keep people from exiting the building). A 5-star rating meets the Tier 1 Immediate Occupancy (IO) structural performance objective.

Table 1-3. Identified Seismic Evaluation Items to Address for an improved ★★ 2-STAR Rating

Evaluation Item	Tier 1 Screening	Description
Load Path	Unknown	Could not verify as drawings were not available during this review and the load path is generally hidden by finishes, etc. From what could be observed on site, it does appear to have a complete load path, however, recommend further investigation for verification.
Torsion	Unknown	The sawtooth roof is believed to be concrete, thus rigid, and subject to torsional consideration. The remaining roofs appear to be flexible wood roofs which are not subject to torsional irregularities. There are insufficient existing information to perform a detailed analysis, however, due the distribution of wall openings at the saw-tooth concrete structure, it appears that there is a potential eccentricity between the centers of mass and rigidity that would result in torsional irregularity. Recommend further investigation, including a site survey to develop an analytical model to verify if a torsional irregularity exists.
Shear Stress Check	Noncompliant	The narrow concrete piers at the longitudinal walls of the sawtooth roof structure appear to be overstressed. Further investigation is recommended.
Transfer to Shear Walls	Unknown	No existing information was available. Further investigation is recommended.
Foundation Dowels	Unknown	No existing information was available. Further investigation is recommended.

Note: All of the evaluation items in Table 3 need to be assessed as Compliant (C) in order to achieve a 2-Star Structural Safety Rating.

Table 1-4. Additional Seismic Evaluation Items to Mitigate or Further Investigate for an improved ★★★ 3-STAR Rating

Evaluation Item	Tier 1 Evaluation	Description
Overturning	Noncompliant	The narrow piers at the long walls of the sawtooth roof structure are shorter than the 8'-9" calculated minimum length for compliance. Recommend further investigation and analysis.
Ties Between Foundation Elements	Unknown	Original structural drawings were not found and connections between foundation elements could not be visually verified during the site visit. Further investigation is recommended.
Complete Frames	Unknown	The pony walls at the Library are supported by a frame, however, the details at the exterior walls could not be verified. There is no sign of a pilaster, so the column must be integrated into the wall. Recommend further investigation.
Reinforcing Steel	Unknown	No existing information was available. Further investigation is recommended.
Deflection Compatibility	Unknown	The columns that support the pony walls at the sawtooth walls are of particular concern and may require further investigation using a rebar scanner or other means to verify the spacing of secondary reinforcement. Further investigation is recommended.
Coupling Beams	Unknown	It's unclear if the spandrel sections over the walls in the long walls (sawtooth roof structure) are intended to be coupling beams between the narrow concrete wall piers. Further investigation is recommended.
Uplift at Pile Caps	Unknown	The foundation type is not known, but due to the heavy structure and what are believed to be poor soils, it is possible piles were used. Connection details were not found as original drawings were not available. Further investigation is recommended.

Note: Tables 3 and 4 are cumulative. All of the evaluation items in Table 4 need to be assessed as Compliant (C) in addition to all of the evaluation items in Table 3 being assessed as Compliant (C), in order to achieve a 3-Star Structural Safety Rating.

The Structural Safety star-rating contained in this report is based on ASCE 41 Tier 1 Screening Checklists only. These seismic screening checklists are often the first step employed by structural engineers when trying to determine the seismic vulnerabilities of existing buildings and to begin a process of mitigating these seismic vulnerabilities. School district facilities management personnel and their design consultants should be able to take advantage of this information to help inform and address seismic risks in existing or future renovation, repair, or modernization projects.

It is important to note that information used for these school seismic screenings was limited to available construction drawings and limited site observations by our team of licensed structural engineers. In some cases, construction drawings were not available for review. Due to the limited scope of the study, our team of engineers were not able to perform more-detailed investigations above ceilings, behind wall finishes, in confined spaces, or in other areas obstructed from view. In many cases, further investigation and engineering analysis may find that items marked as unknown or noncompliant may not require seismic mitigation if it is shown that the existing structure is acceptable in its current state. In these cases, further investigation and engineering analysis should be conducted ahead of a seismic upgrade construction project, especially when a building is marked as having many unknown items.

1.2 Seismic Evaluation Findings

1.2.1 Structural Seismic Deficiencies

The structural seismic deficiencies identified during the Tier 1 evaluation are summarized below. Commentary for each deficiency is also provided based on this evaluation.

Table 1-5. Identified Structural Seismic Deficiencies for Hoquiam Central Elementary School Main Building

Deficiency	Description
Overturning	The narrow piers at the long walls of the sawtooth roof structure are shorter than the 8'-9" calculated minimum length for compliance. Recommend further investigation and analysis.
Shear Stress Check	The narrow concrete piers at the longitudinal walls of the sawtooth roof structure appear to be overstressed. Further investigation is recommended.
Spans	The gymnasium roof appears to be straight sheathed and the spans between lateral force resisting elements exceed 24 feet. The underside of a straight-sheathed roof is also visible in the mechanical room. The locations of shear walls at the north wing is unknown, but assuming no interior shear walls that area is also not compliant. Further investigation is recommended.

1.2.2 Structural Checklist Items Marked as Unknown

Where building structural component seismic adequacy was unknown due to lack of available information or limited observation, the structural checklist items were marked as "unknown". These items require further investigation if definitive determination of compliance or noncompliance is desired. The unknown structural checklist items identified during the Tier 1 evaluation are summarized below. Commentary for each unknown item is also provided based on the evaluation.

Table 1-6. Identified Structural Checklist Items Marked as Unknown for Hoquiam Central Elementary School Main Building

Unknown Item	Description
Load Path	Could not verify as drawings were not available during this review and the load path is generally hidden by finishes, etc. From what could be observed on site, it does appear to have a complete load path, however, recommend further investigation for verification.
Torsion	The sawtooth roof is believed to be concrete, thus rigid, and subject to torsional consideration. The remaining roofs appear to be flexible wood roofs which are not subject to torsional irregularities. There are insufficient existing information to perform a detailed analysis, however, due the distribution of wall openings at the saw-tooth concrete structure, it appears that there is a potential eccentricity between the centers of mass and rigidity that would result in torsional irregularity. Recommend further investigation, including a site survey to develop an analytical model to verify if a torsional irregularity exists.
Liquefaction	The liquefaction potential of site soils is unknown at this time given available information. Moderate to High liquefaction potential is identified per ICOS based on state geologic mapping. Requires further investigation by a licensed geotechnical engineer to determine liquefaction potential.
Surface Fault Rupture	There does not appear to be record of surface faulting in this region; however, investigation by a licensed geotechnical engineer is necessary to verify the surface fault rupture potential.
Ties Between Foundation Elements	Original structural drawings were not found and connections between foundation elements could not be visually verified during the site visit. Further investigation is recommended.
Complete Frames	The pony walls at the Library are supported by a frame, however, the details at the exterior walls could not be verified. There is no sign of a pilaster, so the column must be integrated into the wall. Recommend further investigation.
Reinforcing Steel	No existing information was available. Further investigation is recommended.
Wall Anchorage at Flexible Diaphragms	No existing information was available; any existing connections could not be visually verified during the site visit. Further investigation is recommended.
Transfer to Shear Walls	No existing information was available. Further investigation is recommended.
Foundation Dowels	No existing information was available. Further investigation is recommended.
Deflection Compatibility	The columns that support the pony walls at the sawtooth walls are of particular concern and may require further investigation using a rebar scanner or other means to verify the spacing of secondary reinforcement. Further investigation is recommended.
Coupling Beams	It's unclear if the spandrel sections over the walls in the long walls (sawtooth roof structure) are intended to be coupling beams between the narrow concrete wall piers. Further investigation is recommended.
Uplift at Pile Caps	The foundation type is not known, but due to the heavy structure and what are believed to be poor soils, it is possible piles were used. Connection details were not found as original drawings were not available. Further investigation is recommended.

1.3.1 Nonstructural Seismic Deficiencies

The nonstructural seismic deficiencies identified during the Tier 1 evaluation are summarized below. Commentary for each deficiency is also provided based on this evaluation. Some nonstructural deficiencies may be able to be mitigated by school district staff. Other nonstructural components that require more substantial mitigation may be more appropriately included in a long-term mitigation strategy. Some typical conceptual details for the seismic upgrade of nonstructural components can be found in the FEMA E-74 Excerpts appendix.

Table 1-7. Identified Nonstructural Seismic Deficiencies for Hoquiam Central Elementary School Main Building

Deficiency	Description
CF-2 Tall Narrow Contents. HR-not required; LS-H; PR-MH.	Tall and narrow contents with a height more than 6 feet and a height-to-depth or height-to-width ratio greater than 3-to-1 should be anchored to the structure or to each other.
CF-3 Fall-Prone Contents. HR-not required; LS-H; PR-H.	Equipment and stored items weighing more than 20 lb whose center of mass is more than 4 ft above the adjacent floor level should be braced or otherwise restrained.

1.3.2 Nonstructural Checklist Items Marked as Unknown

Where building nonstructural component seismic adequacy was unknown due to lack of available information or limited observation, the nonstructural checklist items were marked as “unknown”. These items require further investigation if definitive determination of compliance or noncompliance is desired. The unknown nonstructural checklist items identified during the Tier 1 evaluation are summarized below. Commentary for each unknown item is also provided based on the evaluation.

Some nonstructural deficiencies may be able to be mitigated by school district staff. Other nonstructural components that require more substantial mitigation may be more appropriately included in a long-term mitigation strategy. Some typical conceptual details for the seismic upgrade of nonstructural components can be found in the FEMA E-74 Excerpts appendix.

Table 1-8. Identified Nonstructural Checklist Items Marked as Unknown for Hoquiam Central Elementary School Main Building

Unknown Item	Description
LSS-1 Fire Suppression Piping. HR-not required; LS-LMH; PR-LMH.	All spaces except the gym appear to have fire suppression piping, however bracing was not observed. Recommend a licensed fire protection engineer review to verify.
LSS-2 Flexible Couplings. HR-not required; LS-LMH; PR-LMH.	Couplings not observed.
M-1 Ties. HR-not required; LS-LMH; PR-LMH.	Original construction drawings and details were not available. Further investigation is recommended.
M-3 Weakened Planes. HR-not required; LS-LMH; PR-LMH.	As-built information not available at the time of this evaluation. Further investigation is recommended.
M-4 Unreinforced Masonry Backup. HR-LMH; LS-LMH; PR-LMH.	As-built information not available at the time of this evaluation. Further investigation is recommended.
M-6 Anchorage. HR-not required; LS-MH; PR-MH.	As-built information not available at the time of this evaluation. Further investigation is recommended.
ME-3 Tall Narrow Equipment. HR-not required; LS-H; PR-MH.	Not all equipment was able to be verified during site visit. Tall and narrow equipment with a height more than 6 feet and a height-to-depth or height-to-width ratio greater than 3-to-1 should be anchored to the floor slab or adjacent structural walls.

Hoquiam, Central Elementary School, Main Building

17-2 Collapse Prevention Basic Configuration Checklist

Building record drawings have been reviewed, when available, and a non-destructive field investigation has been performed for the subject building. Each of the required checklist items are marked Compliant (C), Noncompliant (NC), Not Applicable (N/A), or Unknown (U). Items marked Compliant indicate conditions that satisfy the performance objective, whereas items marked Noncompliant or Unknown indicate conditions that do not. Certain statements might not apply to the building being evaluated.

Low Seismicity

Building System - General

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Load Path	The structure contains a complete, well-defined load path, including structural elements and connections, that serves to transfer the inertial forces associated with the mass of all elements of the building to the foundation. (Tier 2: Sec. 5.4.1.1; Commentary: Sec. A.2.1.10)				X	Could not verify as drawings were not available during this review and the load path is generally hidden by finishes, etc. From what could be observed on site, it does appear to have a complete load path, however, recommend further investigation for verification.
Adjacent Buildings	The clear distance between the building being evaluated and any adjacent building is greater than 0.25% of the height of the shorter building in low seismicity, 0.5% in moderate seismicity, and 1.5% in high seismicity. (Tier 2: Sec. 5.4.1.2; Commentary: Sec. A.2.1.2)	X				
Mezzanines	Interior mezzanine levels are braced independently from the main structure or are anchored to the seismic-force-resisting elements of the main structure. (Tier 2: Sec. 5.4.1.3; Commentary: Sec. A.2.1.3)			X		No mezzanines found.

Building System - Building Configuration

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Weak Story	The sum of the shear strengths of the seismic-force-resisting system in any story in each direction is not less than 80% of the strength in the adjacent story above. (Tier 2: Sec. 5.4.2.1; Commentary: Sec. A.2.2.2)			X		Building is a single story structure.
Soft Story	The stiffness of the seismic-force-resisting system in any story is not less than 70% of the seismic-force-resisting system stiffness in an adjacent story above or less than 80% of the average seismic-force-resisting system stiffness of the three stories above. (Tier 2: Sec. 5.4.2.2; Commentary: Sec. A.2.2.3)			X		Building is a single story structure.

Vertical Irregularities	All vertical elements in the seismic-force-resisting system are continuous to the foundation. (Tier 2: Sec. 5.4.2.3; Commentary: Sec. A.2.2.4)			X		Building is a single story structure.
Geometry	There are no changes in the net horizontal dimension of the seismic-force-resisting system of more than 30% in a story relative to adjacent stories, excluding one-story penthouses and mezzanines. (Tier 2: Sec. 5.4.2.4; Commentary: Sec. A.2.2.5)			X		Building is a single story structure.
Mass	There is no change in effective mass of more than 50% from one story to the next. Light roofs, penthouses, and mezzanines need not be considered. (Tier 2: Sec. 5.4.2.5; Commentary: Sec. A.2.2.6)			X		Building is a single story structure.
Torsion	The estimated distance between the story center of mass and the story center of rigidity is less than 20% of the building width in either plan dimension. (Tier 2: Sec. 5.4.2.6; Commentary: Sec. A.2.2.7)				X	The sawtooth roof is believed to be concrete, thus rigid, and subject to torsional consideration. The remaining roofs appear to be flexible wood roofs which are not subject to torsional irregularities. There are insufficient existing information to perform a detailed analysis, however, due the distribution of wall openings at the saw-tooth concrete structure, it appears that there is a potential eccentricity between the centers of mass and rigidity that would result in torsional irregularity. Recommend further investigation, including a site survey to develop an analytical model to verify if a torsional irregularity exists.

Moderate Seismicity (Complete the Following Items in Addition to the Items for Low Seismicity)

Geologic Site Hazards

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Liquefaction	Liquefaction-susceptible, saturated, loose granular soils that could jeopardize the building's seismic performance do not exist in the foundation soils at depths within 50 ft (15.2 m) under the building. (Tier 2: Sec. 5.4.3.1; Commentary: Sec. A.6.1.1)				X	The liquefaction potential of site soils is unknown at this time given available information. Moderate to High liquefaction potential is identified per ICOS based on state geologic mapping. Requires further investigation by a licensed geotechnical engineer to determine liquefaction potential.
Slope Failure	The building site is located away from potential earthquake-induced slope failures or rockfalls so that it is unaffected by such failures or is capable of accommodating any predicted movements without failure. (Tier 2: Sec. 5.4.3.1; Commentary: Sec. A.6.1.2)			X		The site is flat.
Surface Fault Rupture	Surface fault rupture and surface displacement at the building site are not anticipated. (Tier 2: Sec. 5.4.3.1; Commentary: Sec. A.6.1.3)				X	There does not appear to be record of surface faulting in this region; however, investigation by a licensed geotechnical engineer is necessary to verify the surface fault rupture potential.

High Seismicity (Complete the Following Items in Addition to the Items for Low and Moderate Seismicity)

Foundation Configuration

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Overturning	The ratio of the least horizontal dimension of the seismic-force-resisting system at the foundation level to the building height (base/height) is greater than 0.6Sa. (Tier 2: Sec. 5.4.3.3; Commentary: Sec. A.6.2.1)		X			The narrow piers at the long walls of the sawtooth roof structure are shorter than the 8'-9" calculated minimum length for compliance. Recommend further investigation and analysis.
Ties Between Foundation Elements	The foundation has ties adequate to resist seismic forces where footings, piles, and piers are not restrained by beams, slabs, or soils classified as Site Class A, B, or C. (Tier 2: Sec. 5.4.3.4; Commentary: Sec. A.6.2.2)				X	Original structural drawings were not found and connections between foundation elements could not be visually verified during the site visit. Further investigation is recommended.

17-24 Collapse Prevention Structural Checklist for Building Types C2 and C2a

Building record drawings have been reviewed, when available, and a non-destructive field investigation has been performed for the subject building. Each of the required checklist items are marked Compliant (C), Noncompliant (NC), Not Applicable (N/A), or Unknown (U). Items marked Compliant indicate conditions that satisfy the performance objective, whereas items marked Noncompliant or Unknown indicate conditions that do not. Certain statements might not apply to the building being evaluated.

Low and Moderate Seismicity

Seismic-Force-Resisting System

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Complete Frames	Steel or concrete frames classified as secondary components form a complete vertical-load-carrying system. (Tier 2: Sec. 5.5.2.5.1; Commentary: Sec. A.3.1.6.1)				X	The pony walls at the Library are supported by a frame, however, the details at the exterior walls could not be verified. There is no sign of a pilaster, so the column must be integrated into the wall. Recommend further investigation.
Redundancy	The number of lines of shear walls in each principal direction is greater than or equal to 2. (Tier 2: Sec.5.5.1.1; Commentary: Sec. A.3.2.1.1)	X				
Shear Stress Check	The shear stress in the concrete shear walls, calculated using the Quick Check procedure of Section 4.4.3.3, is less than the greater of 100 lb/in.2 (0.69 MPa) or 2√f'c. (Tier 2: Sec.5.5.3.1.1; Commentary: Sec. A.3.2.2.1)		X			The narrow concrete piers at the longitudinal walls of the sawtooth roof structure appear to be overstressed. Further investigation is recommended.
Reinforcing Steel	The ratio of reinforcing steel area to gross concrete area is not less than 0.0012 in the vertical direction and 0.0020 in the horizontal direction. (Tier 2: Sec.5.5.3.1.3; Commentary: Sec. A.3.2.2.2)				X	No existing information was available. Further investigation is recommended.

Connections

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Wall Anchorage at Flexible Diaphragms	Exterior concrete or masonry walls that are dependent on flexible diaphragms for lateral support are anchored for out-of-plane forces at each diaphragm level with steel anchors, reinforcing dowels, or straps that are developed into the diaphragm. Connections have strength to resist the connection force calculated in the Quick Check procedure of Section 4.4.3.7. (Tier 2: Sec.5.7.1.1; Commentary: Sec. A.5.1.1)				X	No existing information was available; any existing connections could not be visually verified during the site visit. Further investigation is recommended.

Transfer to Shear Walls	Diaphragms are connected for transfer of seismic forces to the shear walls. (Tier 2: Sec.5.7.2; Commentary: Sec. A.5.2.1)				X	No existing information was available. Further investigation is recommended.
Foundation Dowels	Wall reinforcement is doweled into the foundation with vertical bars equal in size and spacing to the vertical wall reinforcing directly above the foundation. (Tier 2: Sec.5.7.3.4; Commentary: Sec. A.5.3.5)				X	No existing information was available. Further investigation is recommended.

High Seismicity (Complete the Following Items in Addition to the Items for Low and Moderate Seismicity)

Seismic-Force-Resisting System

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Deflection Compatibility	Secondary components have the shear capacity to develop the flexural strength of the components. (Tier 2: Sec.5.5.2.5.2; Commentary: Sec. A.3.1.6.2)				X	The columns that support the pony walls at the sawtooth walls are of particular concern and may require further investigation using a rebar scanner or other means to verify the spacing of secondary reinforcement. Further investigation is recommended.
Flat Slabs	Flat slabs or plates not part of the seismic-force-resisting system have continuous bottom steel through the column joints. (Tier 2: Sec.5.5.2.5.3; Commentary: Sec. A.3.1.6.3)			X		
Coupling Beams	The ends of both walls to which the coupling beam is attached are supported at each end to resist vertical loads caused by overturning. (Tier 2: Sec.5.5.3.2.1; Commentary: Sec. A.3.2.2.3)				X	It's unclear if the spandrel sections over the walls in the long walls (sawtooth roof structure) are intended to be coupling beams between the narrow concrete wall piers. Further investigation is recommended.

Diaphragms (Stiff or Flexible)

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Diaphragm Continuity	The diaphragms are not composed of split-level floors and do not have expansion joints. (Tier 2: Sec.5.6.1.1; Commentary: Sec. A.4.1.1)	X				The pony walls at the sawtooth roof appear to have solid piers, albeit in an alternating pattern between adjacent pony walls, to transfer roof diaphragm forces from one sawtooth sloping diaphragm to the next.
Openings at Shear Walls	Diaphragm openings immediately adjacent to the shear walls are less than 25% of the wall length. (Tier 2: Sec.5.6.1.3; Commentary: Sec. A.4.1.4)			X		

Flexible Diaphragms

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Cross Ties	There are continuous cross ties between diaphragm chords. (Tier 2: Sec.5.6.1.2; Commentary: Sec. A.4.1.2)	X				The timber trusses at the gym roof as well as concrete beams at the sawtooth roof appear to demonstrate cross ties at the roof diaphragms.
Straight Sheathing	All straight-sheathed diaphragms have aspect ratios less than 2-to-1 in the direction being considered. (Tier 2: Sec.5.6.2; Commentary: Sec. A.4.2.1)	X				
Spans	All wood diaphragms with spans greater than 24 ft (7.3 m) consist of wood structural panels or diagonal sheathing. (Tier 2: Sec.5.6.2; Commentary: Sec. A.4.2.2)		X			The gymnasium roof appears to be straight sheathed and the spans between lateral force resisting elements exceed 24 feet. The underside of a straight-sheathed roof is also visible in the mechanical room. The locations of shear walls at the north wing is unknown, but assuming no interior shear walls that area is also not compliant. Further investigation is recommended.
Diagonally Sheathed and Unblocked Diaphragms	All diagonally sheathed or unblocked wood structural panel diaphragms have horizontal spans less than 40 ft (12.2 m) and aspect ratios less than or equal to 4 to-1. (Tier 2: Sec.5.6.2; Commentary: Sec. A.4.2.3)			X		
Other Diaphragms	Diaphragms do not consist of a system other than wood, metal deck, concrete, or horizontal bracing. (Tier 2: Sec.5.6.5; Commentary: Sec. A.4.7.1)	X				

Connections

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Uplift at Pile Caps	Pile caps have top reinforcement, and piles are anchored to the pile caps. (Tier 2: Sec.5.7.3.5; Commentary: Sec. A.5.3.8)				X	The foundation type is not known, but due to the heavy structure and what are believed to be poor soils, it is possible piles were used. Connection details were not found as original drawings were not available. Further investigation is recommended.

Hoquiam, Central Elementary School, Main Building

17-38 Nonstructural Checklist

Notes:
C = Compliant, NC = Noncompliant, N/A = Not Applicable, and U = Unknown.
Performance Level: HR = Hazards Reduced, LS = Life Safety, and PR = Position Retention.
Level of Seismicity: L = Low, M = Moderate, and H = High

Life Safety Systems

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
LSS-1 Fire Suppression Piping. HR-not required; LS-LMH; PR-LMH.	Fire suppression piping is anchored and braced in accordance with NFPA-13. (Tier 2: Sec. 13.7.4; Commentary: Sec. A.7.13.1)				X	All spaces except the gym appear to have fire suppression piping, however bracing was not observed. Recommend a licensed fire protection engineer review to verify.
LSS-2 Flexible Couplings. HR-not required; LS-LMH; PR-LMH.	Fire suppression piping has flexible couplings in accordance with NFPA-13. (Tier 2: Sec. 13.7.4; Commentary: Sec. A.7.13.2)				X	Couplings not observed.
LSS-3 Emergency Power. HR-not required; LS-LMH; PR-LMH.	Equipment used to power or control Life Safety systems is anchored or braced. (Tier 2: Sec. 13.7.7; Commentary: Sec. A.7.12.1)			X		The only life safety equipment observed were emergency exit lights, which have batteries.
LSS-4 Stair and Smoke Ducts. HR-not required; LS-LMH; PR-LMH.	Stair pressurization and smoke control ducts are braced and have flexible connections at seismic joints. (Tier 2: Sec. 13.7.6; Commentary: Sec. A.7.14.1)			X		
LSS-5 Sprinkler Ceiling Clearance. HR-not required; LS-MH; PR-MH.	Penetrations through panelized ceilings for fire suppression devices provide clearances in accordance with NFPA-13. (Tier 2: Sec. 13.7.4; Commentary: Sec. A.7.13.3)	X				
LSS-6 Emergency Lighting. HR-not required; LS-not required; PR-LMH	Emergency and egress lighting equipment is anchored or braced. (Tier 2: Sec. 13.7.9; Commentary: Sec. A.7.3.1)			X		

Hazardous Materials

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
HM-1 Hazardous Material Equipment. HR-LMH; LS-LMH; PR-LMH.	Equipment mounted on vibration isolators and containing hazardous material is equipped with restraints or snubbers. (Tier 2: Sec. 13.7.1; Commentary: Sec. A.7.12.2)			X		Hazardous material items not observed on site.
HM-2 Hazardous Material Storage. HR-LMH; LS-LMH; PR-LMH.	Breakable containers that hold hazardous material, including gas cylinders, are restrained by latched doors, shelf lips, wires, or other methods. (Tier 2: Sec. 13.8.3; Commentary: Sec. A.7.15.1)			X		

HM-3 Hazardous Material Distribution. HR-MH; LS-MH; PR-MH.	Piping or ductwork conveying hazardous materials is braced or otherwise protected from damage that would allow hazardous material release. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.4)			X		
HM-4 Shutoff Valves. HR-MH; LS-MH; PR-MH.	Piping containing hazardous material, including natural gas, has shutoff valves or other devices to limit spills or leaks. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.3)			X		
HM-5 Flexible Couplings. HR-LMH; LS-LMH; PR-LMH.	Hazardous material ductwork and piping, including natural gas piping, have flexible couplings. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.15.4)			X		
HM-6 Piping or Ducts Crossing Seismic Joints. HR-MH; LS-MH; PR-MH.	Piping or ductwork carrying hazardous material that either crosses seismic joints or isolation planes or is connected to independent structures has couplings or other details to accommodate the relative seismic displacements. (Tier 2: Sec. 13.7.3, 13.7.5, 13.7.6; Commentary: Sec. A.7.13.6)			X		

Partitions

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
P-1 Unreinforced Masonry. HR-LMH; LS-LMH; PR-LMH.	Unreinforced masonry or hollow-clay tile partitions are braced at a spacing of at most 10 ft (3.0 m) in Low or Moderate Seismicity, or at most 6 ft (1.8 m) in High Seismicity. (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.1.1)			X		
P-2 Heavy Partitions Supported by Ceilings. HR-LMH; LS-LMH; PR-LMH.	The tops of masonry or hollow-clay tile partitions are not laterally supported by an integrated ceiling system. (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.2.1)			X		
P-3 Drift. HR-not required; LS-MH; PR-MH.	Rigid cementitious partitions are detailed to accommodate the following drift ratios: in steel moment frame, concrete moment frame, and wood frame buildings, 0.02; in other buildings, 0.005. (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.1.2)			X		
P-4 Light Partitions Supported by Ceilings. HR-not required; LS-not required; PR-MH.	The tops of gypsum board partitions are not laterally supported by an integrated ceiling system. (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.2.1)			X		
P-5 Structural Separations. HR-not required; LS-not required; PR-MH.	Partitions that cross structural separations have seismic or control joints. (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.1.3)			X		
P-6 Tops. HR-not required; LS-not required; PR-MH.	The tops of ceiling-high framed or panelized partitions have lateral bracing to the structure at a spacing equal to or less than 6 ft (1.8 m). (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.1.4)			X		

Ceilings

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
C-1 Suspended Lath and Plaster. HR-H; LS-MH; PR-LMH.	Suspended lath and plaster ceilings have attachments that resist seismic forces for every 12 ft2 (1.1 m2) of area. (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.3)			X		
C-2 Suspended Gypsum Board. HR-not required; LS-MH; PR-LMH.	Suspended gypsum board ceilings have attachments that resist seismic forces for every 12 ft2 (1.1 m2) of area. (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.3)			X		
C-3 Integrated Ceilings. HR-not required; LS-not required; PR-MH.	Integrated suspended ceilings with continuous areas greater than 144 ft2 (13.4 m2) and ceilings of smaller areas that are not surrounded by restraining partitions are laterally restrained at a spacing no greater than 12 ft (3.6 m) with members attached to the structure above. Each restraint location has a minimum of four diagonal wires and compression struts, or diagonal members capable of resisting compression. (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.2)			X		
C-4 Edge Clearance. HR-not required; LS-not required; PR-MH.	The free edges of integrated suspended ceilings with continuous areas greater than 144 ft2 (13.4 m2) have clearances from the enclosing wall or partition of at least the following: in Moderate Seismicity, 1/2 in. (13 mm); in High Seismicity, 3/4 in. (19 mm). (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.4)			X		
C-5 Continuity Across Structure Joints. HR-not required; LS-not required; PR-MH.	The ceiling system does not cross any seismic joint and is not attached to multiple independent structures. (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.5)			X		
C-6 Edge Support. HR-not required; LS-not required; PR-H.	The free edges of integrated suspended ceilings with continuous areas greater than 144 ft2 (13.4 m2) are supported by closure angles or channels not less than 2 in. (51 mm) wide. (Tier 2: Sec. 13.6.4 ; Commentary: Sec. A.7.2.6)			X		
C-7 Seismic Joints. HR-not required; LS-not required; PR-H.	Acoustical tile or lay-in panel ceilings have seismic separation joints such that each continuous portion of the ceiling is no more than 2,500 ft2 (232.3 m2) and has a ratio of long-to-short dimension no more than 4-to-1. (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.7)			X		

Light Fixtures

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
LF-1 Independent Support. HR-not required; LS-MH; PR-MH.	Light fixtures that weigh more per square foot than the ceiling they penetrate are supported independent of the grid ceiling suspension system by a minimum of two wires at diagonally opposite corners of each fixture. (Tier 2: Sec. 13.6.4, 13.7.9; Commentary: Sec. A.7.3.2)	X				
LF-2 Pendant Supports. HR-not required; LS-not required; PR-H.	Light fixtures on pendant supports are attached at a spacing equal to or less than 6 ft. Unbraced suspended fixtures are free to allow a 360-degree range of motion at an angle not less than 45 degrees from horizontal without contacting adjacent components. Alternatively, if rigidly supported and/or braced, they are free to move with the structure to which they are attached without damaging adjoining components. Additionally, the connection to the structure is capable of accommodating the movement without failure. (Tier 2: Sec. 13.7.9; Commentary: Sec. A.7.3.3)			X		
LF-3 Lens Covers. HR-not required; LS-not required; PR-H.	Lens covers on light fixtures are attached with safety devices. (Tier 2: Sec. 13.7.9; Commentary: Sec. A.7.3.4)			X		

Cladding and Glazing

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
CG-1 Cladding Anchors. HR-MH; LS-MH; PR-MH.	Cladding components weighing more than 10 lb/ft2 (0.48 kN/m2) are mechanically anchored to the structure at a spacing equal to or less than the following: for Life Safety in Moderate Seismicity, 6 ft (1.8 m); for Life Safety in High Seismicity and for Position Retention in any seismicity, 4 ft (1.2 m) (Tier 2: Sec. 13.6.1; Commentary: Sec. A.7.4.1)			X		
CG-2 Cladding Isolation. HR-not required; LS-MH; PR-MH.	For steel or concrete moment-frame buildings, panel connections are detailed to accommodate a story drift ratio by the use of rods attached to framing with oversize holes or slotted holes of at least the following: for Life Safety in Moderate Seismicity, 0.01; for Life Safety in High Seismicity and for Position Retention in any seismicity, 0.02, and the rods have a length-to-diameter ratio of 4.0 or less. (Tier 2: Sec. 13.6.1; Commentary: Sec. A.7.4.3)			X		

CG-3 Multi-Story Panels. HR-MH; LS-MH; PR-MH.	For multi-story panels attached at more than one floor level, panel connections are detailed to accommodate a story drift ratio by the use of rods attached to framing with oversize holes or slotted holes of at least the following: for Life Safety in Moderate Seismicity, 0.01; for Life Safety in High Seismicity and for Position Retention in any seismicity, 0.02, and the rods have a length-to-diameter ratio of 4.0 or less. (Tier 2: Sec. 13.6.1; Commentary: Sec. A.7.4.4)			X		
CG-4 Threaded Rods. HR-not required; LS-MH; PR-MH.	Threaded rods for panel connections detailed to accommodate drift by bending of the rod have a length-to-diameter ratio greater than 0.06 times the story height in inches for Life Safety in Moderate Seismicity and 0.12 times the story height in inches for Life Safety in High Seismicity and Position Retention in any seismicity. (Tier 2: Sec. 13.6.1; Commentary: Sec. A.7.4.9)			X		
CG-5 Panel Connections. HR-MH; LS-MH; PR-MH.	Cladding panels are anchored out of plane with a minimum number of connections for each wall panel, as follows: for Life Safety in Moderate Seismicity, 2 connections; for Life Safety in High Seismicity and for Position Retention in any seismicity, 4 connections. (Tier 2: Sec. 13.6.1.4; Commentary: Sec. A.7.4.5)			X		
CG-6 Bearing Connections. HR-MH; LS-MH; PR-MH.	Where bearing connections are used, there is a minimum of two bearing connections for each cladding panel. (Tier 2: Sec. 13.6.1.4; Commentary: Sec. A.7.4.6)			X		
CG-7 Inserts. HR-MH; LS-MH; PR-MH.	Where concrete cladding components use inserts, the inserts have positive anchorage or are anchored to reinforcing steel. (Tier 2: Sec. 13.6.1.4; Commentary: Sec. A.7.4.7)			X		
CG-8 Overhead Glazing. HR-not required; LS-MH; PR-MH.	Glazing panes of any size in curtain walls and individual interior or exterior panes more than 16 ft2 (1.5 m2) in area are laminated annealed or laminated heat-strengthened glass and are detailed to remain in the frame when cracked. (Tier 2: Sec. 13.6.1.5; Commentary: Sec. A.7.4.8)			X		

Masonry Veneer

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
M-1 Ties. HR-not required; LS-LMH; PR-LMH.	Masonry veneer is connected to the backup with corrosion-resistant ties. There is a minimum of one tie for every 2-2/3 ft2 (0.25 m2), and the ties have spacing no greater than the following: for Life Safety in Low or Moderate Seismicity, 36 in. (914 mm); for Life Safety in High Seismicity and for Position Retention in any seismicity, 24 in. (610 mm). (Tier 2: Sec. 13.6.1.2; Commentary: Sec. A.7.5.1)				X	Original construction drawings and details were not available. Further investigation is recommended.
M-2 Shelf Angles. HR-not required; LS-LMH; PR-LMH.	Masonry veneer is supported by shelf angles or other elements at each floor above the ground floor. (Tier 2: Sec. 13.6.1.2; Commentary: Sec. A.7.5.2)			X		
M-3 Weakened Planes. HR-not required; LS-LMH; PR-LMH.	Masonry veneer is anchored to the backup adjacent to weakened planes, such as at the locations of flashing. (Tier 2: Sec. 13.6.1.2; Commentary: Sec. A.7.5.3)				X	As-built information not available at the time of this evaluation. Further investigation is recommended.
M-4 Unreinforced Masonry Backup. HR-LMH; LS-LMH; PR-LMH.	There is no unreinforced masonry backup. (Tier 2: Sec. 13.6.1.1, 13.6.1.2; Commentary: Sec. A.7.7.2)				X	As-built information not available at the time of this evaluation. Further investigation is recommended.
M-5 Stud Tracks. HR-not required; LS-MH; PR-MH.	For veneer with coldformed steel stud backup, stud tracks are fastened to the structure at a spacing equal to or less than 24 in. (610 mm) on center. (Tier 2: Sec. 13.6.1.1, 13.6.1.2; Commentary: Sec. A.7.6.)			X		
M-6 Anchorage. HR-not required; LS-MH; PR-MH.	For veneer with concrete block or masonry backup, the backup is positively anchored to the structure at a horizontal spacing equal to or less than 4 ft along the floors and roof. (Tier 2: Sec. 13.6.1.1, 13.6.1.2; Commentary: Sec. A.7.7.1)				X	As-built information not available at the time of this evaluation. Further investigation is recommended.
M-7 Weep Holes. HR-not required; LS-not required; PR-MH.	In veneer anchored to stud walls, the veneer has functioning weep holes and base flashing. (Tier 2: Sec. 13.6.1.2; Commentary: Sec. A.7.5.6)			X		
M-8 Openings. HR-not required; LS-not required; PR-MH.	For veneer with cold-formed-steel stud backup, steel studs frame window and door openings. (Tier 2: Sec. 13.6.1.1, 13.6.1.2; Commentary: Sec. A.7.6.2)			X		

Parapets, Cornices, Ornamentation, and Appendages

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
PCOA-1 URM Parapets or Cornices. HR-LMH; LS-LMH; PR-LMH.	Laterally unsupported unreinforced masonry parapets or cornices have height-tothickness ratios no greater than the following: for Life Safety in Low or Moderate Seismicity, 2.5; for Life Safety in High Seismicity and for Position Retention in any seismicity, 1.5. (Tier 2: Sec. 13.6.5; Commentary: Sec. A.7.8.1)			X		
PCOA-2 Canopies. HR-not required; LS-LMH; PR-LMH.	Canopies at building exits are anchored to the structure at a spacing no greater than the following: for Life Safety in Low or Moderate Seismicity, 10 ft (3.0 m); for Life Safety in High Seismicity and for Position Retention in any seismicity, 6 ft (1.8 m). (Tier 2: Sec. 13.6.6; Commentary: Sec. A.7.8.2)			X		
PCOA-3 Concrete Parapets. HR-H; LS-MH; PR-LMH.	Concrete parapets with height-to-thickness ratios greater than 2.5 have vertical reinforcement. (Tier 2: Sec. 13.6.5; Commentary: Sec. A.7.8.3)			X		
PCOA-4 Appendages. HR-MH; LS-MH; PR-LMH.	Cornices, parapets, signs, and other ornamentation or appendages that extend above the highest point of anchorage to the structure or cantilever from components are reinforced and anchored to the structural system at a spacing equal to or less than 6 ft (1.8 m). This evaluation statement item does not apply to parapets or cornices covered by other evaluation statements. (Tier 2: Sec. 13.6.6; Commentary: Sec. A.7.8.4)			X		

Masonry Chimneys

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
MC-1 URM Chimneys. HR-LMH; LS-LMH; PR-LMH.	Unreinforced masonry chimneys extend above the roof surface no more than the following: for Life Safety in Low or Moderate Seismicity, 3 times the least dimension of the chimney; for Life Safety in High Seismicity and for Position Retention in any seismicity, 2 times the least dimension of the chimney. (Tier 2: Sec. 13.6.7; Commentary: Sec. A.7.9.1)			X		
MC-2 Anchorage. HR-LMH; LS-LMH; PR-LMH.	Masonry chimneys are anchored at each floor level, at the topmost ceiling level, and at the roof. (Tier 2: Sec. 13.6.7; Commentary: Sec. A.7.9.2)			X		

Stairs

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
S-1 Stair Enclosures. HR-not required; LS-LMH; PR-LMH.	Hollow-clay tile or unreinforced masonry walls around stair enclosures are restrained out of plane and have height-to-thickness ratios not greater than the following: for Life Safety in Low or Moderate Seismicity, 15-to-1; for Life Safety in High Seismicity and for Position Retention in any seismicity, 12-to-1. (Tier 2: Sec. 13.6.2, 13.6.8; Commentary: Sec. A.7.10.1)			X		
S-2 Stair Details. HR-not required; LS-LMH; PR-LMH.	The connection between the stairs and the structure does not rely on post-installed anchors in concrete or masonry, and the stair details are capable of accommodating the drift calculated using the Quick Check procedure of Section 4.4.3.1 for moment-frame structures or 0.5 in. for all other structures without including any lateral stiffness contribution from the stairs. (Tier 2: Sec. 13.6.8; Commentary: Sec. A.7.10.2)			X		

Contents and Furnishings

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
CF-1 Industrial Storage Racks. HR-LMH; LS-MH; PR-MH.	Industrial storage racks or pallet racks more than 12 ft high meet the requirements of ANSI/RMI MH 16.1 as modified by ASCE 7, Chapter 15. (Tier 2: Sec. 13.8.1; Commentary: Sec. A.7.11.1)			X		
CF-2 Tall Narrow Contents. HR-not required; LS-H; PR-MH.	Contents more than 6 ft (1.8 m) high with a height-to-depth or height-to-width ratio greater than 3-to-1 are anchored to the structure or to each other. (Tier 2: Sec. 13.8.2; Commentary: Sec. A.7.11.2)		X			Tall and narrow contents with a height more than 6 feet and a height-to-depth or height-to-width ratio greater than 3-to-1 should be anchored to the structure or to each other.
CF-3 Fall-Prone Contents. HR-not required; LS-H; PR-H.	Equipment, stored items, or other contents weighing more than 20 lb (9.1 kg) whose center of mass is more than 4 ft (1.2 m) above the adjacent floor level are braced or otherwise restrained. (Tier 2: Sec. 13.8.2; Commentary: Sec. A.7.11.3)		X			Equipment and stored items weighing more than 20 lb whose center of mass is more than 4 ft above the adjacent floor level should be braced or otherwise restrained.
CF-4 Access Floors. HR-not required; LS-not required; PR-MH.	Access floors more than 9 in. (229 mm) high are braced. (Tier 2: Sec. 13.6.10; Commentary: Sec. A.7.11.4)			X		

CF-5 Equipment on Access Floors. HR-not required; LS-not required; PR-MH.	Equipment and other contents supported by access floor systems are anchored or braced to the structure independent of the access floor. (Tier 2: Sec. 13.7.7 13.6.10; Commentary: Sec. A.7.11.5)			X		
CF-6 Suspended Contents. HR-not required; LS-not required; PR-H.	Items suspended without lateral bracing are free to swing from or move with the structure from which they are suspended without damaging themselves or adjoining components. (Tier 2: Sec. 13.8.2; Commentary: Sec. A.7.11.6)			X		

Mechanical and Electrical Equipment

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
ME-1 Fall-Prone Equipment. HR-not required; LS-H; PR-H.	Equipment weighing more than 20 lb (9.1 kg) whose center of mass is more than 4 ft (1.2 m) above the adjacent floor level, and which is not in-line equipment, is braced. (Tier 2: Sec. 13.7.1 13.7.7; Commentary: Sec. A.7.12.4)	X				
ME-2 In-Line Equipment. HR-not required; LS-H; PR-H.	Equipment installed in line with a duct or piping system, with an operating weight more than 75 lb (34.0 kg), is supported and laterally braced independent of the duct or piping system. (Tier 2: Sec. 13.7.1; Commentary: Sec. A.7.12.5)			X		None found.
ME-3 Tall Narrow Equipment. HR-not required; LS-H; PR-MH.	Equipment more than 6 ft (1.8 m) high with a height-to-depth or height-to-width ratio greater than 3-to-1 is anchored to the floor slab or adjacent structural walls. (Tier 2: Sec. 13.7.1 13.7.7; Commentary: Sec. A.7.12.6)				X	Not all equipment was able to be verified during site visit. Tall and narrow equipment with a height more than 6 feet and a height-to-depth or height-to-width ratio greater than 3-to-1 should be anchored to the floor slab or adjacent structural walls.
ME-4 Mechanical Doors. HR-not required; LS-not required; PR-MH.	Mechanically operated doors are detailed to operate at a story drift ratio of 0.01. (Tier 2: Sec. 13.6.9; Commentary: Sec. A.7.12.7)			X		
ME-5 Suspended Equipment. HR-not required; LS-not required; PR-H.	Equipment suspended without lateral bracing is free to swing from or move with the structure from which it is suspended without damaging itself or adjoining components. (Tier 2: Sec. 13.7.1, 13.7.7; Commentary: Sec. A.7.12.8)			X		
ME-6 Vibration Isolators. HR-not required; LS-not required; PR-H.	Equipment mounted on vibration isolators is equipped with horizontal restraints or snubbers and with vertical restraints to resist overturning. (Tier 2: Sec. 13.7.1; Commentary: Sec. A.7.12.9)			X		
ME-7 Heavy Equipment. HR-not required; LS-not required; PR-H.	Floor supported or platform-supported equipment weighing more than 400 lb (181.4 kg) is anchored to the structure. (Tier 2: Sec. 13.7.1, 13.7.7; Commentary: Sec. A.7.12.10)			X		

ME-8 Electrical Equipment. HR-not required; LS-not required; PR-H.	Electrical equipment is laterally braced to the structure. (Tier 2: Sec. 13.7.7; Commentary: Sec. A.7.12.11)			X		
ME-9 Conduit Couplings. HR-not required; LS-not required; PR-H.	Conduit greater than 2.5 in. (64 mm) trade size that is attached to panels, cabinets, or other equipment and is subject to relative seismic displacement has flexible couplings or connections. (Tier 2: Sec. 13.7.8; Commentary: Sec. A.7.12.12)			X		

Piping

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
PP-1 Flexible Couplings. HR-not required; LS-not required; PR-H.	Fluid and gas piping has flexible couplings. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.2)			X		
PP-2 Fluid and Gas Piping. HR-not required; LS-not required; PR-H.	Fluid and gas piping is anchored and braced to the structure to limit spills or leaks. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.4)			X		
PP-3 C-Clamps. HR-not required; LS-not required; PR-H.	One-sided C-clamps that support piping larger than 2.5 in. (64 mm) in diameter are restrained. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.5)			X		
PP-4 Piping Crossing Seismic Joints. HR-not required; LS-not required; PR-H.	Piping that crosses seismic joints or isolation planes or is connected to independent structures has couplings or other details to accommodate the relative seismic displacements. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.6)			X		

Ducts

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
D-1 Duct Bracing. HR-not required; LS-not required; PR-H.	Rectangular ductwork larger than 6 ft2 (0.56 m2) in cross-sectional area and round ducts larger than 28 in. (711 mm) in diameter are braced. The maximum spacing of transverse bracing does not exceed 30 ft (9.2 m). The maximum spacing of longitudinal bracing does not exceed 60 ft (18.3 m). (Tier 2: Sec. 13.7.6; Commentary: Sec. A.7.14.2)			X		
D-2 Duct Support. HR-not required; LS-not required; PR-H.	Ducts are not supported by piping or electrical conduit. (Tier 2: Sec. 13.7.6; Commentary: Sec. A.7.14.3)			X		
D-3 Ducts Crossing Seismic Joints. HR-not required; LS-not required; PR-H.	Ducts that cross seismic joints or isolation planes or are connected to independent structures have couplings or other details to accommodate the relative seismic displacements. (Tier 2: Sec. 13.7.6; Commentary: Sec. A.7.14.4)			X		

Elevators

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
EL-1 Retainer Guards. HR-not required; LS-H; PR-H.	Sheaves and drums have cable retainer guards. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.1)			X		
EL-2 Retainer Plate. HR-not required; LS-H; PR-H.	A retainer plate is present at the top and bottom of both car and counterweight. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.2)			X		
EL-3 Elevator Equipment. HR-not required; LS-not required; PR-H.	Equipment, piping, and other components that are part of the elevator system are anchored. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.3)			X		
EL-4 Seismic Switch. HR-not required; LS-not required; PR-H.	Elevators capable of operating at speeds of 150 ft/min or faster are equipped with seismic switches that meet the requirements of ASME A17.1 or have trigger levels set to 20% of the acceleration of gravity at the base of the structure and 50% of the acceleration of gravity in other locations. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.4)			X		
EL-5 Shaft Walls. HR-not required; LS-not required; PR-H.	Elevator shaft walls are anchored and reinforced to prevent toppling into the shaft during strong shaking. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.5)			X		
EL-6 Counterweight Rails. HR-not required; LS-not required; PR-H.	All counterweight rails and divider beams are sized in accordance with ASME A17.1. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.6)			X		
EL-7 Brackets. HR-not required; LS-not required; PR-H.	The brackets that tie the car rails and the counterweight rail to the structure are sized in accordance with ASME A17.1. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.7)			X		
EL-8 Spreader Bracket. HR-not required; LS-not required; PR-H.	Spreader brackets are not used to resist seismic forces. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.8)			X		
EL-9 Go-Slow Elevators. HR-not required; LS-not required; PR-H.	The building has a go-slow elevator system. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.9)			X		

Appendix B: Concept-Level Seismic Upgrade Figures

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Central Elementary School Seismic Upgrades – Main Building

Washington State School Seismic Safety Assessments Project – Hoquiam School District #28 – June 2021

Figure 1 – Building Layout

PHASE **2**

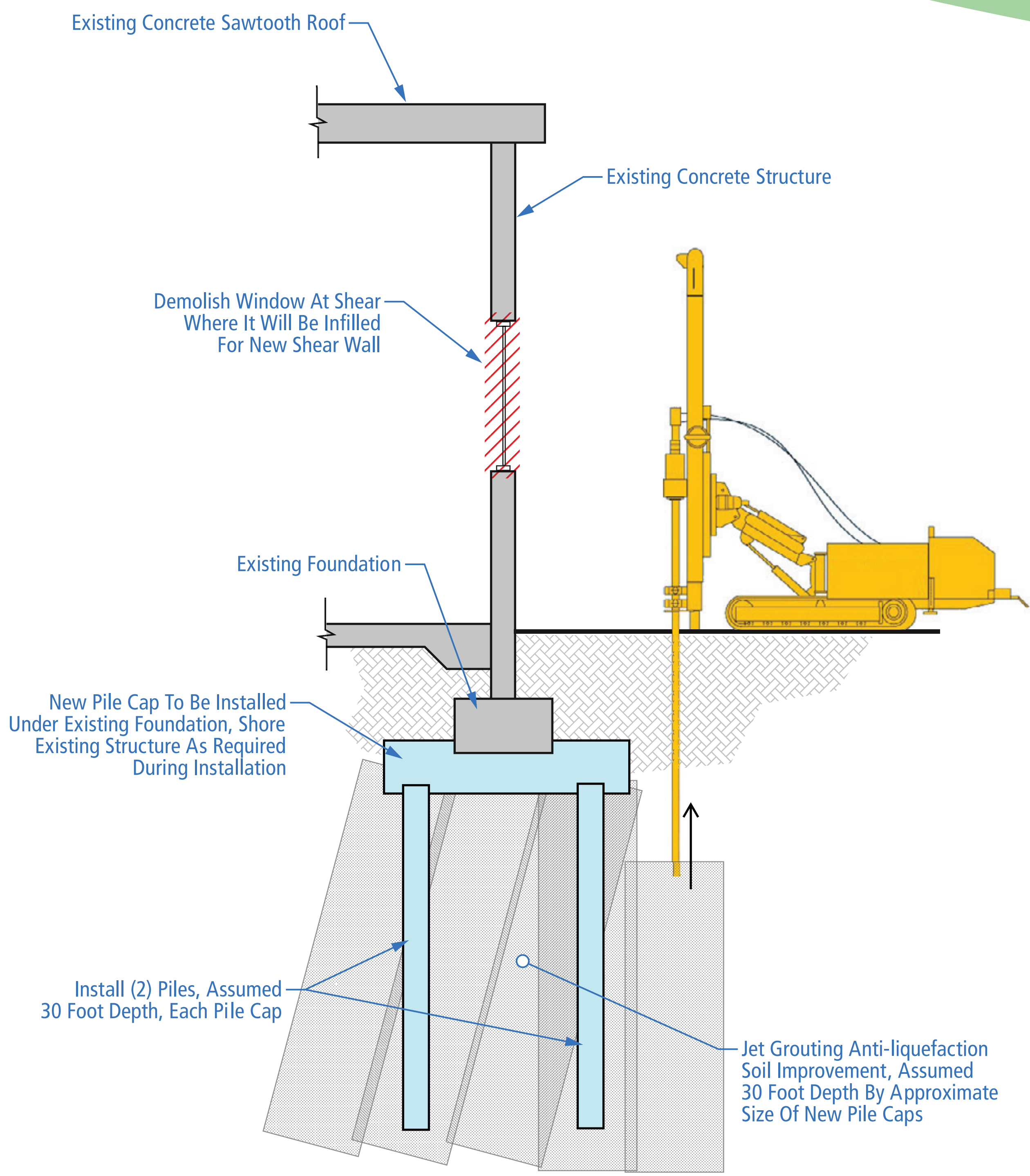
LEGEND

Typical Location Of New Shear Walls, In Fill Windows & Strong Back Existing Walls At Exterior, Refer To Figure 4 For Sectional View

Central Elementary School Seismic Upgrades – Main Building

Washington State School Seismic Safety Assessments Project – Hoquiam School District #28 – June 2021

Figure 2 – Example Typical Shear Wall Elevation



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wsp

Central Elementary School Seismic Upgrades – Main Building

Washington State School Seismic Safety Assessments Project – Hoquiam School District #28 – June 2021

Figure 3 – Foundation Detail - New Piles & Cap with Soil Improvements

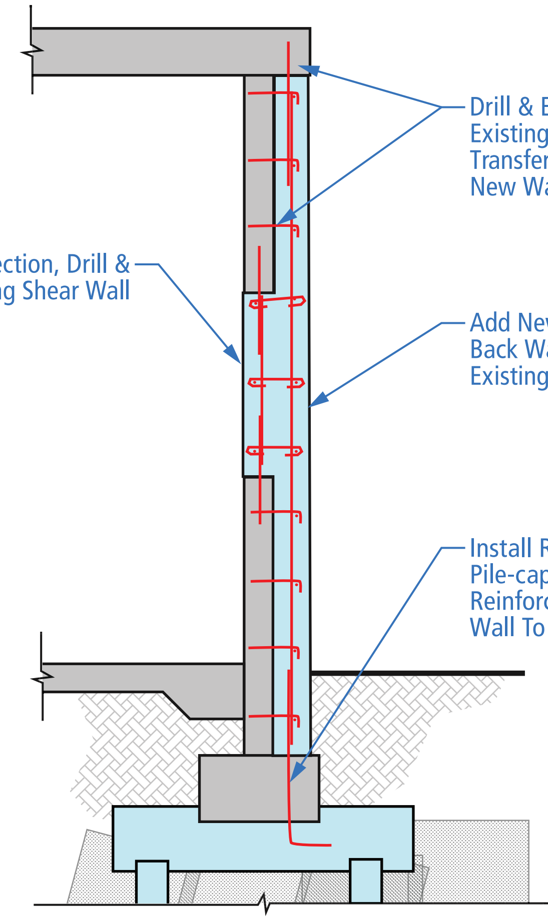

Figure 4 – Shear Wall Section

Appendix C: Opinion of Probable Construction Costs

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Name:	**Wa State School Seismic Safety Assessment Phase 2**
Second Name:	**Central Elementary School**
Location:	**Hoquiam, WA**
Design Phase:	**ROM Cost Estimates**
Date of Estimate:	**February 15, 2021**
Date of Revision:	**April 9, 2021**
Month of Cost Basis:	**1Q, 2021**

Central Elementary School

Master Estimate Summary

Project Name	Construction Cost Type	Estimated Construction Cost
Central Elementary School	Structural Costs	$2,934,200
Central Elementary School	Non-Structural Costs	$880,260
TOTAL ESTIMATED CONSTRUCTION COST	⟶	**$3,814,461**

Soft Costs	Soft Costs % Construction Cost	Estimated Soft Costs
Project Soft Cost Allowance	40.0%	**$1,525,784**
		Sum of the Above
TOTAL ESTIMATED PROJECT COST	⟶	**$5,340,245**

Estimate Assumptions:

The ROM Construction Cost estimates are based on the Concept Design Report for the Project.
Construction Escalation is not included. Costs are current as of the month of Cost Basis noted above right.

Estimate Qualifications:

The ROM estimates are not be relied on solely for proforma development and financial decisions.
Further design work is required to determine construction budgets.
All Buildings Estimated to the 5' foot line for Utilities, All Sitework is estimated to go with any combination of the buildings and alternatives.
The ROM estimates do not include any Hazardous Material Abatement/Disposal.
For Construction Cost Markups they are additive, not cumulative. Percentages are added to the previous subtotal rather than the direct cost subtotal.
Owner Soft Costs Allowance are: A/E design fees, QA/QC, Project Administration, Owners Project Contingency, Average Washington State Sale Tax and
Estimated labor is based on an 8 hour per day shift 5 days a week. Accelerated schedule work of overtime has not been included.
Estimated labor is based on working on unoccupied facility without phased construction.
Estimate is based on a competitive public bid with at least 3 bona fide submitted and unrescinded general contractor bids.
Estimate is based on a competitive public bid with a minimum 6 week bidding schedule and no significant addendums within 2 weeks of bid opening.
State of Washington General Contractor/ Construction Manager (GC/CM) contracts typically raises construction costs. It is Not Included in this estimate.
Estimated construction cost is for the entire project. This estimate is not intended to be used for other projects.
Please consult the cost estimator for any modifications to this estimate. Unilaterally adding and deleting markups, scope of work, schedule, specifications, plans and bid forms could incorrectly restate the project construction cost.
Construction reserve contingency for change orders is not included in the estimate.
Sole source supply of materials and/ or installers typically results in a 40% to 100% premium on costs over open specifications.

PRODIMS

Structural Costs

Name:	Wa State School Seismic Safety Assessment Phase 2
Second Name:	Central Elementary School
Location:	Hoquiam, WA
Design Phase:	ROM Cost Estimates
Date of Estimate:	February 15, 2021
Date of Revision:	April 9, 2021
Month of Cost Basis:	1Q, 2021

Areas	sqft
Building Area	39,000
Total Areas	39,000

520 Kirkland Way, Suite 301
Kirkland, WA 98033
Phone: 425-828-0500 Fax: 425-828-0700
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Central Elementary School

Construction Cost Estimate

Subtotal Direct Cost From the Estimate Detail Below $ 1,993,456

	Percentage of Previous Subtotal	Amount	Running Subtotal
Scope Contingency	10.0%	$ 199,346	$ 2,192,802
General Conditions	10.0%	$ 199,346	$ 2,392,148
Home Office Overhead	5.0%	$ 99,673	$ 2,491,821
Profit	6.0%	$ 119,607	$ 2,611,428
Escalation Included-Costs in 4Q, 2021 Dollars	12.4%	$ 322,772	$ 2,934,200
Washington State Sales Tax - Included in Soft Costs			

Total Markups Applied to the Direct Cost 47.19%
Markups are multiplied on each subtotal- They are not multiplied from the direct cost

		$/sqft
TOTAL ESTIMATED CONSTRUCTION COST--	**$ 2,934,200**	**$ 75.24**
-20% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --	**$ 2,347,360**	**$ 60.19**
+50% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --	**$ 4,401,301**	**$ 112.85**

Please see the Master Summary for Assumptions and Qualifications for ROM Cost Estimates

Direct Cost of Construction

WBS	Description	Quantity	U of M	Labor	Labor Total	Material	Material Total	Equipment	Equipment Total	Total $/U of M	Direct Cost
1 - Seismic Retrofit											
Foundations											
	Jet Grouting of the Soil for Ground Improvement	2,088.9	cuyd	$ 45.90	$ 95,880.00	$ 89.10	$ 186,120.00	$ 8.10	$ 16,920.00	$ 143.10	$ 298,920.00
	Pin Pile - 4" Dia x 30' Long	94	each	$ 1,187.20	$ 111,596.80	$ 667.80	$ 62,773.20	$ 111.30	$ 10,462.20	$ 1,966.30	$ 184,832.20
	Underpinning Existing Foundation at Each Location - Bidder Design - Including Excavation and Backfill	47	each	$ 3,520.00	$ 165,440.00	$ 1,980.00	$ 93,060.00	$ 330.00	$ 15,510.00	$ 5,830.00	$ 274,010.00
	Pile Caps - Excavation, Backfill, Formwork, Concrete, Reinforcing and detailing for a complete system - 4'w x 10'w	139.3	cuyd	$ 761.60	$ 106,059.85	$ 428.40	$ 59,658.67	$ 71.40	$ 9,943.11	$ 1,261.40	$ 175,661.63
Substructure											
	Demo/Reinstall Slab on Grade System for New Footings Installation.	7,520	sqft	$ 9.90	$ 74,448.00	$ 8.10	$ 60,912.00	$ 1.08	$ 8,121.60	$ 19.08	$ 143,481.60
Superstructure											
Roof Systems											
	Shotcrete 8" Thick Shear Wall with Rebar Including Drill and Epoxy in Rebar and Core Drill Through Footings to New Pile Caps and Forms as Required	54.0	cuyd	$ 474.50	$ 25,623.00	$ 175.50	$ 9,477.00	$ 39.00	$ 2,106.00	$ 689.00	$ 37,206.00
	Exterior Wall Covering of New Concrete Piers	2,300	sqft	$ 21.35	$ 49,105.00	$ 13.65	$ 31,395.00	$ 2.10	$ 4,830.00	$ 37.10	$ 85,330.00
	Remove Existing Windows	420	sqft	$ 2.88	$ 1,210.86	$ 0.22	$ 91.14	$ 0.19	$ 78.12	$ 3.29	$ 1,380.12
	Add SIMPSON LTT ANCHOR nailed to Joist and Install Anchor Bolt in Concrete Wal	238	each	$ 159.75	$ 38,020.50	$ 65.25	$ 15,529.50	$ 13.50	$ 3,213.00	$ 238.50	$ 56,763.00
Roofing System											
	Remove Roofing System Down to Plywood Deck	19,665	sqft	$ 4.04	$ 79,397.44	$ 0.21	$ 4,178.81	$ 0.26	$ 5,014.58	$ 4.51	$ 88,590.83
	New Membrane Roofing System with R-38 Rigid Insulation, Flashing and Trim and Downspout Roof Drainage System	19,665	sqft	$ 8.78	$ 172,560.38	$ 10.73	$ 210,907.13	$ 1.17	$ 23,008.05	$ 20.67	$ 406,475.55

WBS	Description	Quantity	U of M	Labor	Labor Total	Material	Material Total	Equipment	Equipment Total	Total $/U of M	Direct Cost
Interior Wall/Door/Casework/Specialties Systems											
	Remove and Reinstall Floor Finish Systems-Allow 50% of the Floor Area	19,500	sqft	$ 3.01	$ 58,636.50	$ 1.84	$ 35,938.50	$ 0.29	$ 5,674.50	$ 5.14	$ 100,249.50
	Remove Ceiling and Reinstall New ACT Ceiling Systems - Allow 50% of the Floor Area	19,500	sqft	$ 4.22	$ 82,212.00	$ 2.58	$ 50,388.00	$ 0.41	$ 7,956.00	$ 7.21	$ 140,556.00
Subtotal of the Direct Cost of Construction				**Central Elementary School**							**$ 1,993,456**

PRODIMS

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Kirkland, WA 98033
Phone: 425-828-0500 Fax: 425-828-0700
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Non-Structural Costs

Name:	Wa State School Seismic Safety Assessment Phase 2	Areas	sqft
Second Name:	Central Elementary School	Building Area	39,000
Location:	Hoquiam, WA		
Design Phase:	ROM Cost Estimates		
Date of Estimate:	February 15, 2021		
Date of Revision:	April 9, 2021		
Month of Cost Basis:	1Q, 2021	Total Areas	39,000

Central Elementary School

Construction Cost Estimate

Subtotal Direct Cost From the Estimate Detail Below $ 598,037

	Percentage of Previous Subtotal	Amount		Running Subtotal	
Scope Contingency	10.0%	$	59,804	$	657,841
General Conditions	10.0%	$	59,804	$	717,644
Home Office Overhead	5.0%	$	29,902	$	747,546
Profit	6.0%	$	35,882	$	783,428
Escalation Included-Costs in 4Q, 2021 Dollars	12.4%	$	96,832	$	880,260
Washington State Sales Tax - Included in Soft Costs					

Total Markups Applied to the Direct Cost 47.19%
Markups are multiplied on each subtotal- They are not multiplied from the direct cost

			$/sqft
TOTAL ESTIMATED CONSTRUCTION COST--	**$**	**880,260**	**$ 22.57**
-20% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --	**$**	**704,208**	**$ 18.06**
+50% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --	**$**	**1,320,390**	**$ 33.86**

Please see the Master Summary for Assumptions and Qualifications for ROM Cost Estimates

Direct Cost of Construction

WBS	Description	Quantity	U of M	Labor	Labor Total	Material	Material Total	Equipment	Equipment Total	Total $/U of M	Direct Cost
	2- Non- Structural Demo/Restoration*										
	Exteriors, Interiors and M/E/P/FP systems										
	Interior Wall/Door/Casework/Specialties Systems										
	Mechanical/Electrical/Fire Protection Systems *	39,000	sqft	$ 7.96	$ 310,302.18	$ 6.51	$ 253,883.60	$ 0.87	$ 33,851.15	$ 15.33	$ 598,036.93
	*Allows 30 percent of existing nonstructural systems M/E/P/FP require upgrades/replacement.										
	Subtotal of the Direct Cost of Construction			**Central Elementary School**							**$ 598,037**

Appendix D: Earthquake Performance Assessment Tool (EPAT) Worksheet

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Washington Schools Earthquake Performance Assessment Tool (EPAT)
RESULTS SUMMARY

District Name	Hoquiam	**Existing Building Life Safety Risk & Priority for Retrofit or Replacement**
School Name	Central Elementary School	
Building Name	Main Building	Very High

Building Data

HAZUS Building Type	C2	Concrete Shear Walls
Year Built	1952	These parameters determine the capacity of the existing building to withstand earthquake forces.
Building Design Code	<1973 UBC	
Existing Building Code Level	Pre	
Geographic Area	Coastal	
Severe Vertical Irregularity	No	Buildings with irregularities have greater earthquake damage than otherwise similar buildings that are regular.
Moderate Vertical Irregularity	No	
Plan Irregularity	Yes	

Seismic Data

Earthquake Ground Shaking Hazard Level	Very High	Frequency and severity of earthquakes at this site
Percentile S_s Among WA K-12 Campuses	95%	Earthquake ground shaking hazard is higher than 95% of WA campuses.
Site Class (Soil or Rock Type)	E	Soft Clay Soil
Liquefaction Potential	Moderate to High	Liquefaction increases the risk of major damage to a building
Combined Earthquake Hazard Level	Extremely High	Earthquake ground shaking and liquefaction potential

Severe Earthquake Event (Design Basis Earthquake Ground Motion)[1]

Building State	**Building Damage Estimate**[2]	**Probability Building is not Repairable**[3]	**Life Safety**[4] **Risk Level**	**Most Likely Post-Earthquake Tagging**[5]
Existing Building	86%	86%	Very High	Red
Life Safety Retrofit Building	25%	16%	Low	Green/Yellow
Current Code Building	20%	12%	Very Low	Green/Yellow

1. 2/3rds of the 2% in 50 year ground motion
2. Percentage of building replacement value.
3. Probability building is in the Extensive or Complete damage states. For existing buildings, the probability that the building is not economically repairable may be higher: some buildings in the Moderate Damage state are also likely to be demolished.
4. Based on probability of Complete Damage State.
5. Most likely post-earthquake damage state per ATC-20.

Source for the Data Entered into the Tool

Building Evaluated By:	Ben Fisher
Person(s) Who Entered Data in EPAT:	Rami Sabra, Reid Middleton
User Overrides of Default Parameters:	Building Design Code Year, Site Class, Liquefaction

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Appendix E: Existing Drawings

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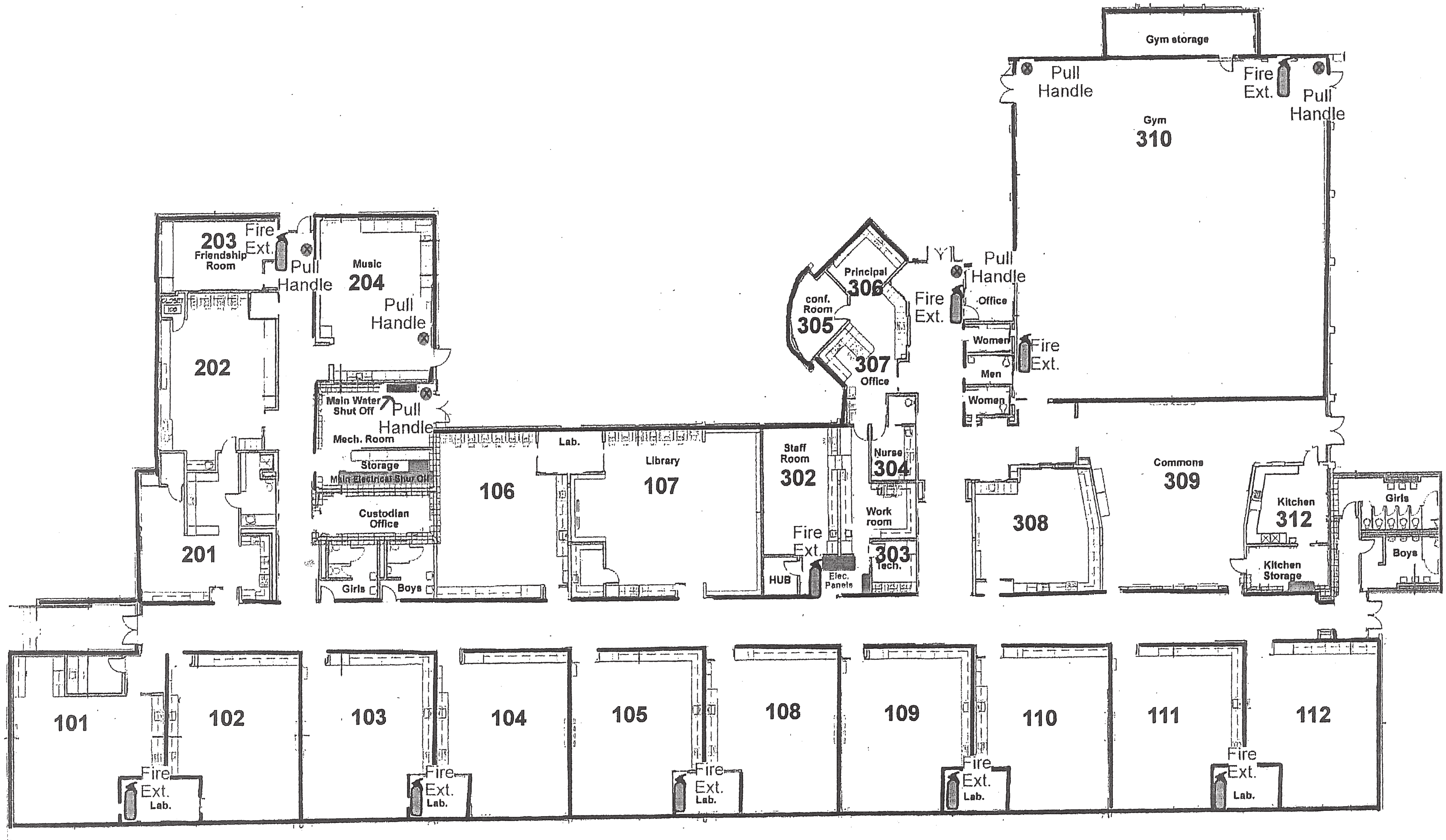
Central School



9/9/09

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Appendix F: FEMA E-74 Nonstructural Seismic Bracing Excerpts

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Life Safety Systems

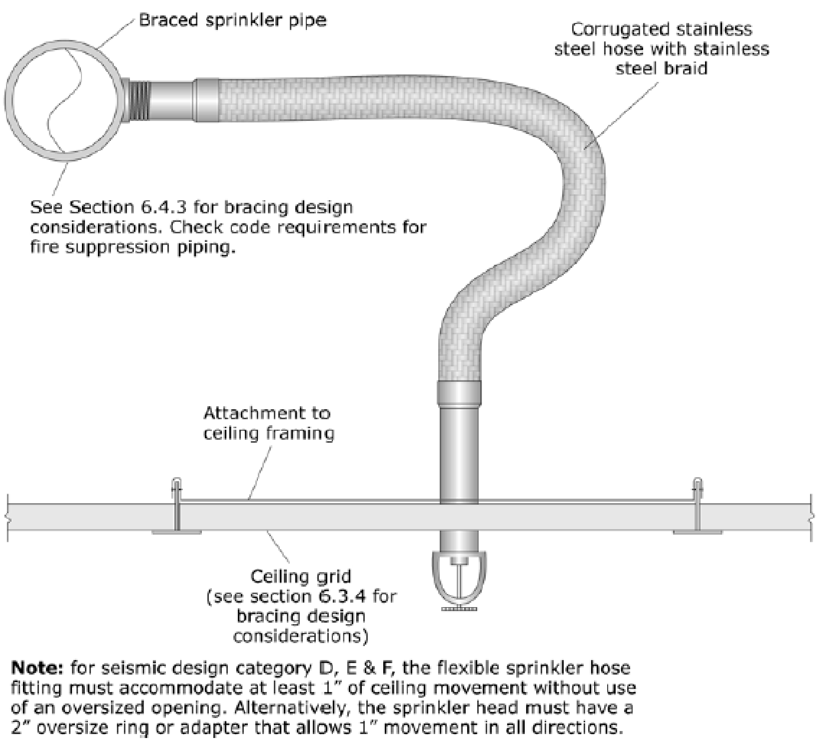


Figure G-1. Flexible Sprinkler Drop.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

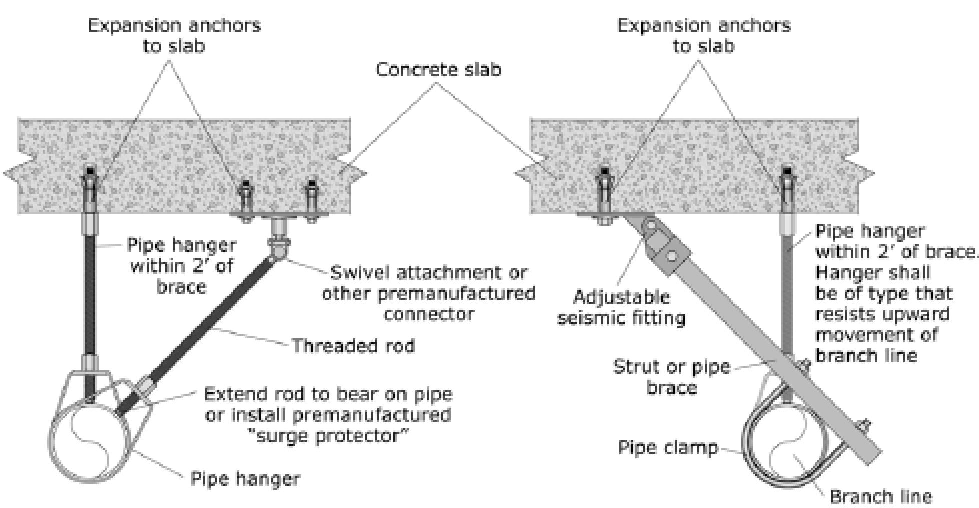


Figure G-2. End of Line Restraint.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Partitions

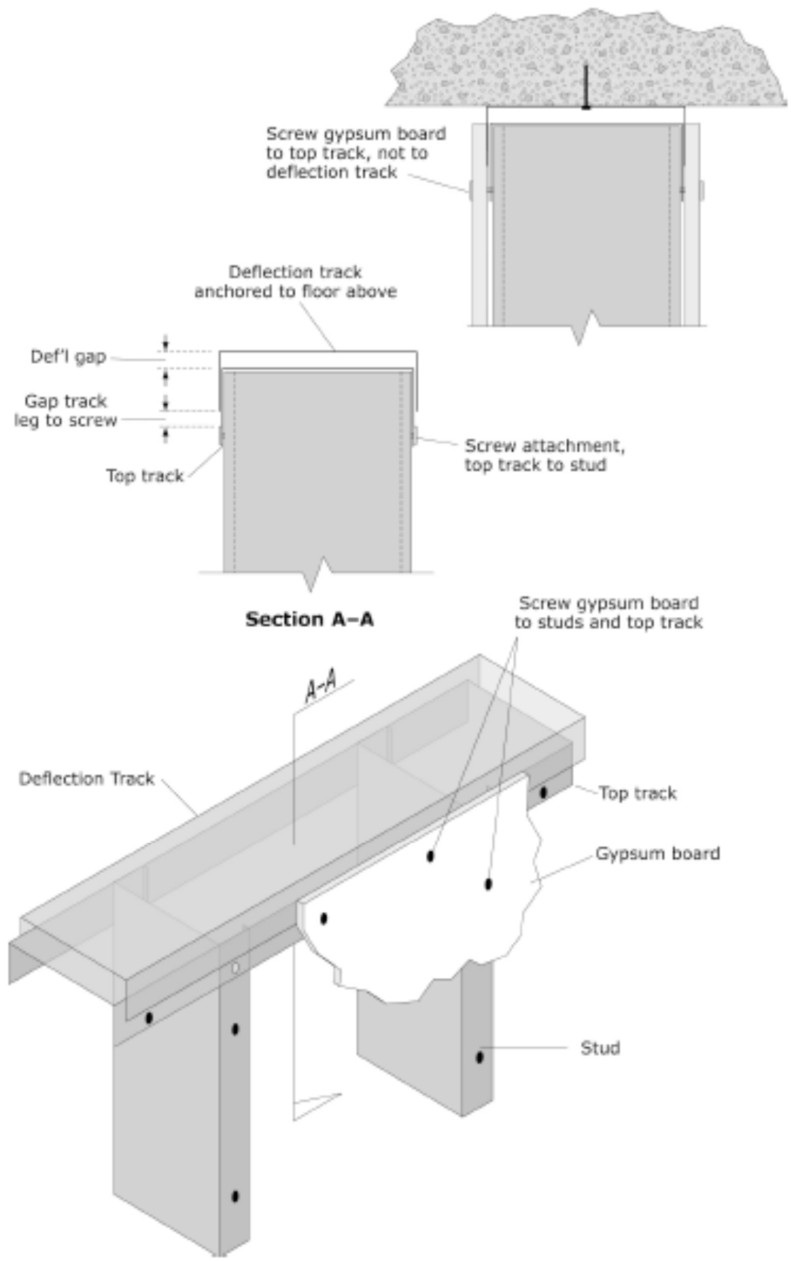


Figure G-3. Mitigation Schemes for Bracing the Tops of Metal Stud Partitions Walls.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

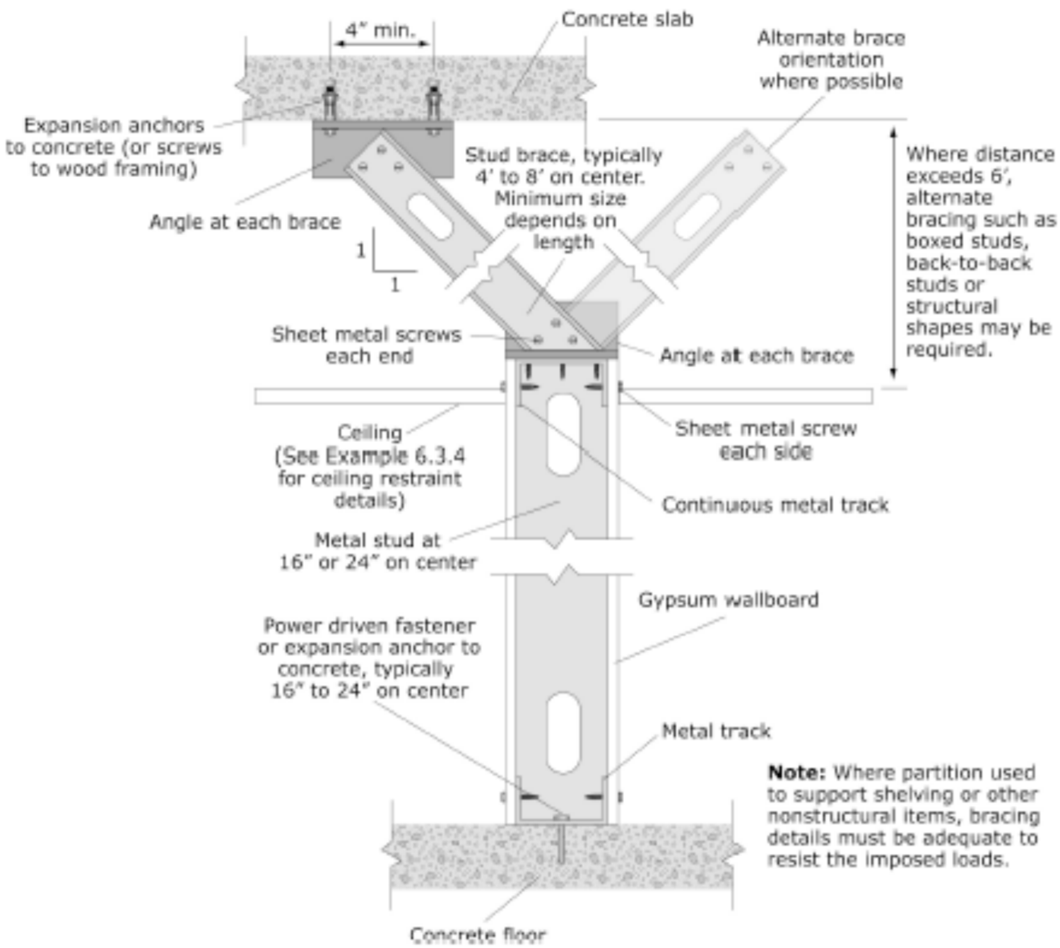
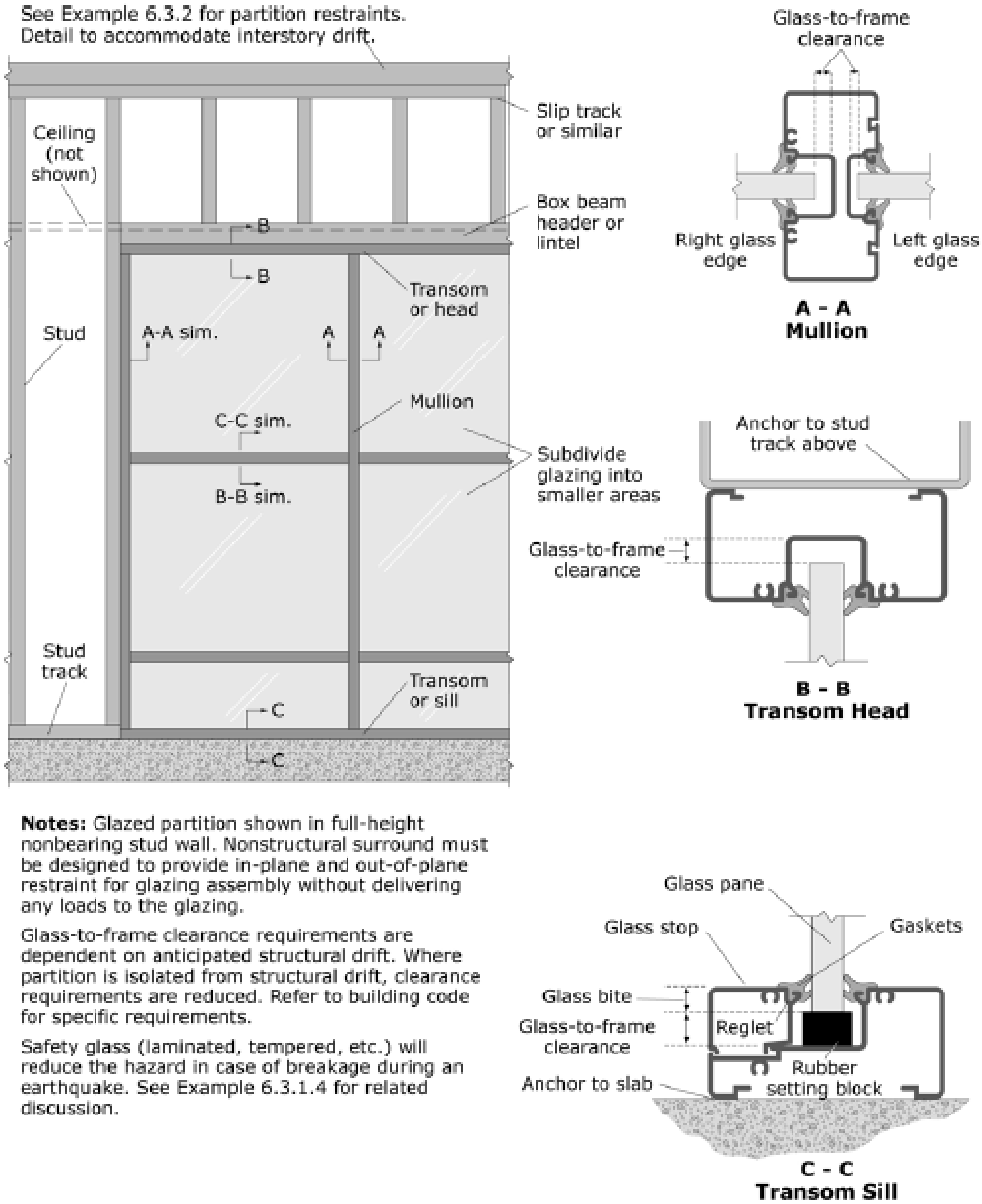


Figure G-4. Mitigation Schemes for Bracing the Tops of Metal Stud Partitions Walls.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Notes: Glazed partition shown in full-height nonbearing stud wall. Nonstructural surround must be designed to provide in-plane and out-of-plane restraint for glazing assembly without delivering any loads to the glazing.

Glass-to-frame clearance requirements are dependent on anticipated structural drift. Where partition is isolated from structural drift, clearance requirements are reduced. Refer to building code for specific requirements.

Safety glass (laminated, tempered, etc.) will reduce the hazard in case of breakage during an earthquake. See Example 6.3.1.4 for related discussion.

Figure G-5. Full-height Glazed Partition.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

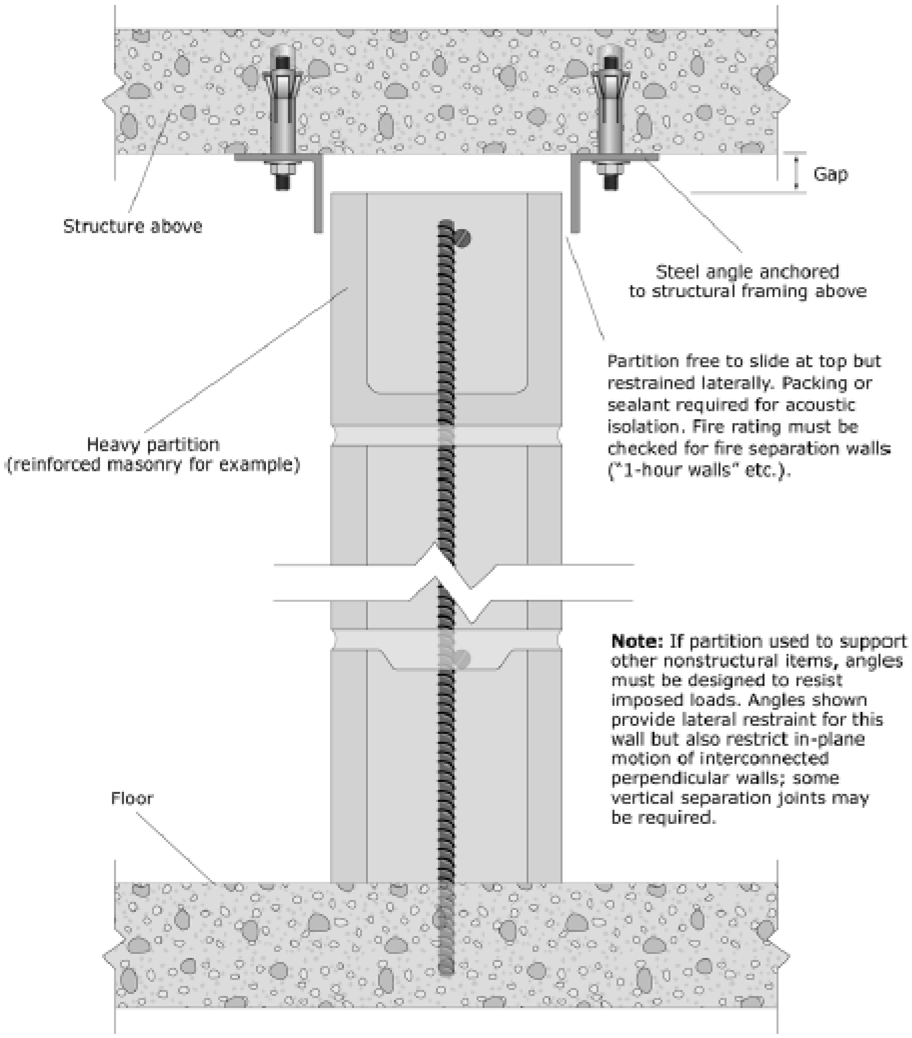


Figure G-6. Full-height Heavy Partition.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

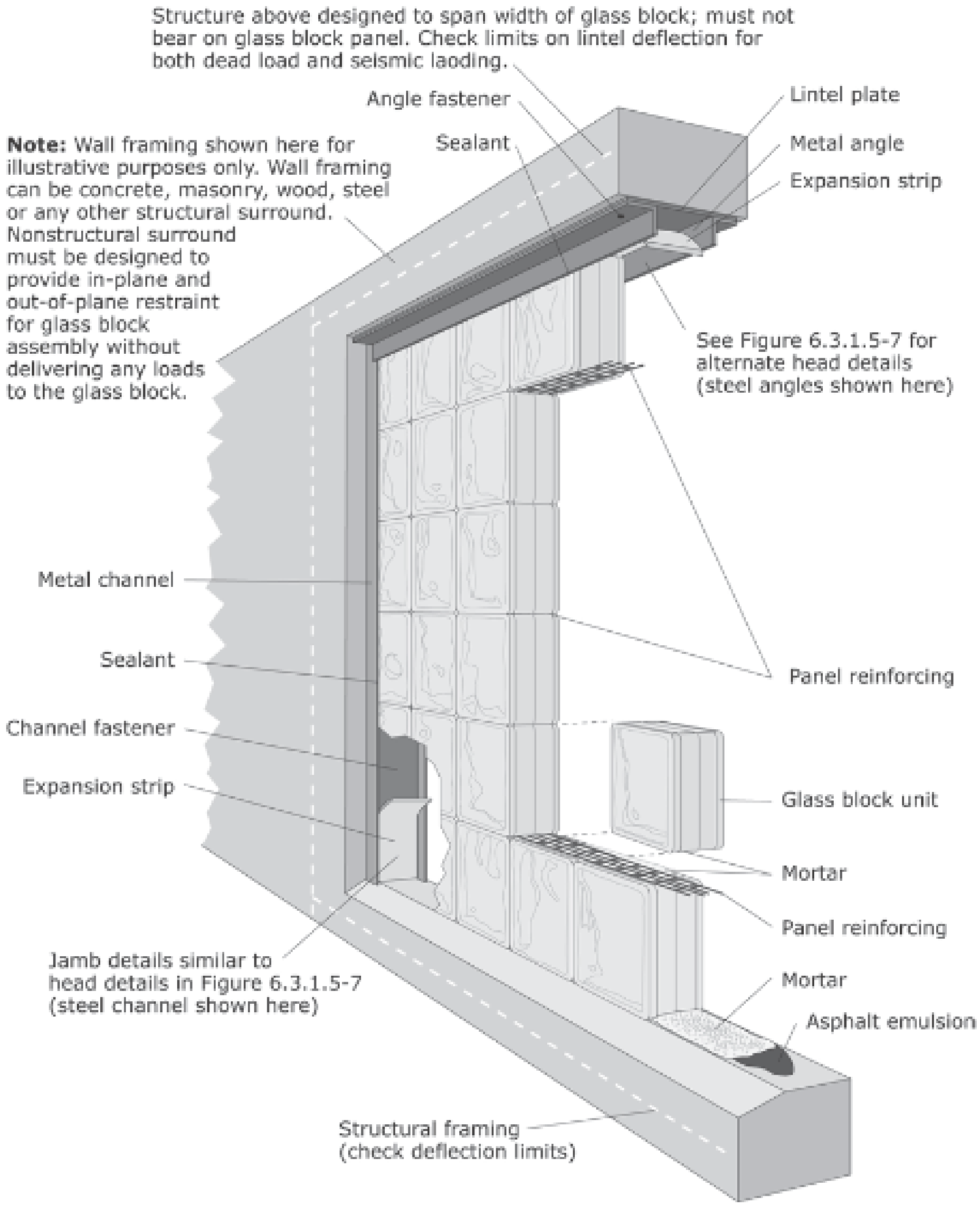


Figure G-7. Typical Glass Block Panel Details.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Ceilings

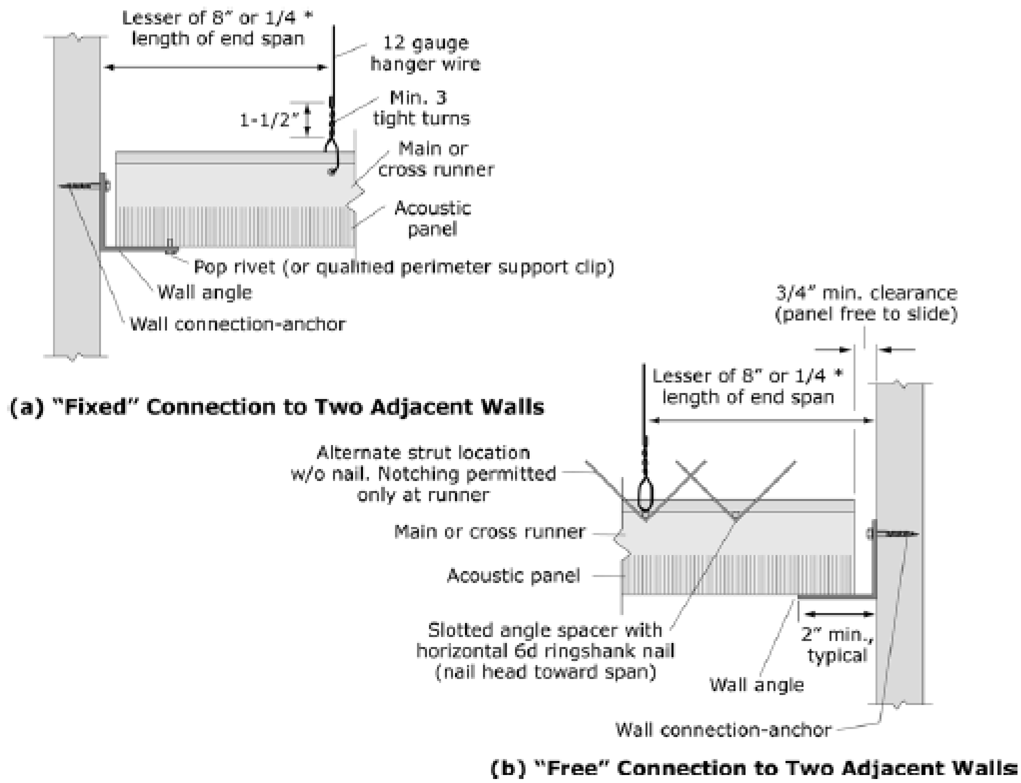
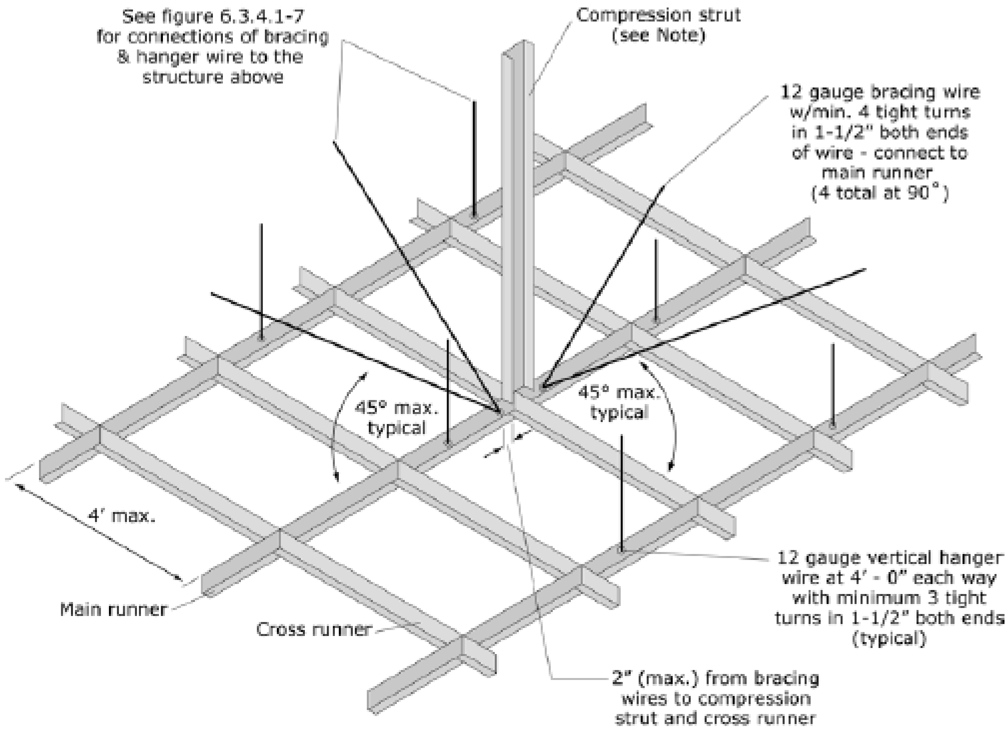


Figure G-8. Suspension System for Acoustic Lay-in Panel Ceilings – Edge Conditions.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Note: Compression strut shall not replace hanger wire. Compression strut consists of a steel section attached to main runner with 2 - #12 sheet metal screws and to structure with 2 - #12 screws to wood or 1/4" min. expansion anchor to structure. Size of strut is dependent on distance between ceiling and structure ($l/r \leq 200$). A 1" diameter conduit can be used for up to 6', a 1-5/8" X 1-1/4" metal stud can be used for up to 10'

Per DSA IR 25-5, ceiling areas less than 144 sq. ft, or fire rated ceilings less than 96 sq. ft., surrounded by walls braced to the structure above do not require lateral bracing assemblies when they are attached to two adjacent walls. (ASTM E580 does not require lateral bracing assemblies for ceilings less than 1000 sq. ft.; see text.)

Figure G-9. Suspension System for Acoustic Lay-in Panel Ceilings – General Bracing Assembly.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

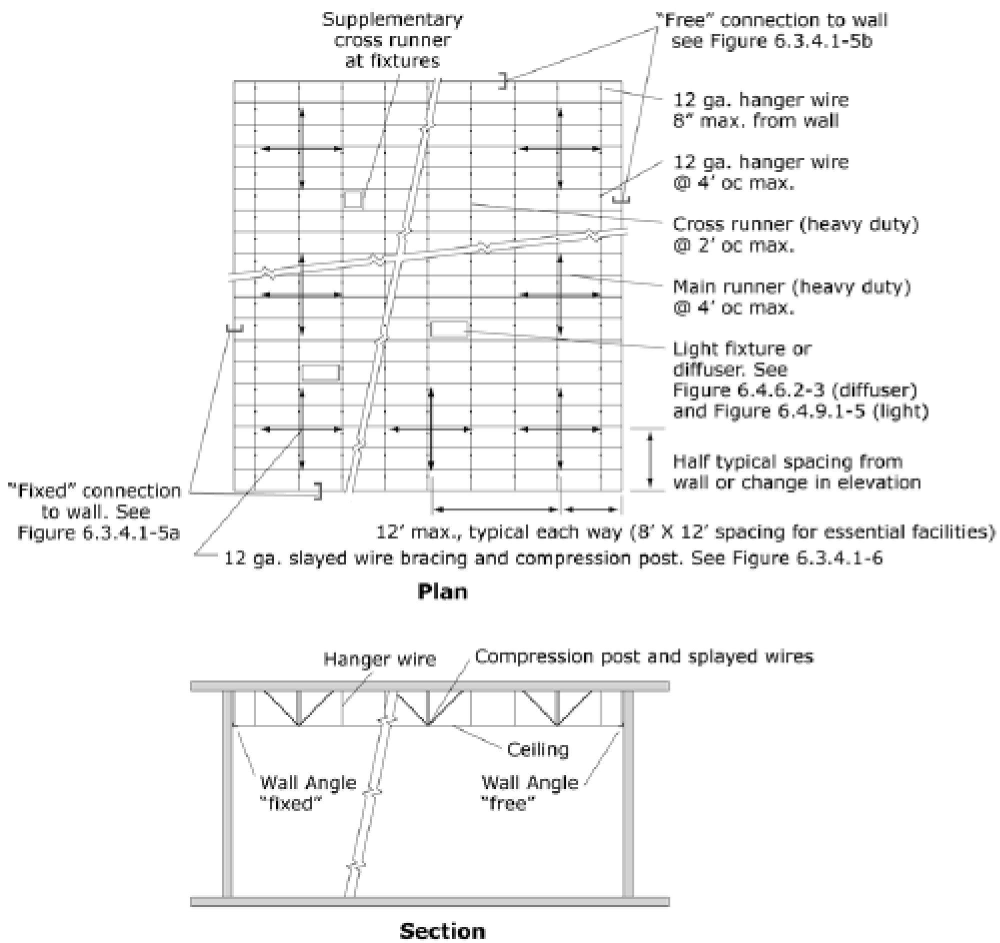


Figure G-10. Suspension System for Acoustic Lay-in Panel Ceilings – General Bracing Layout.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

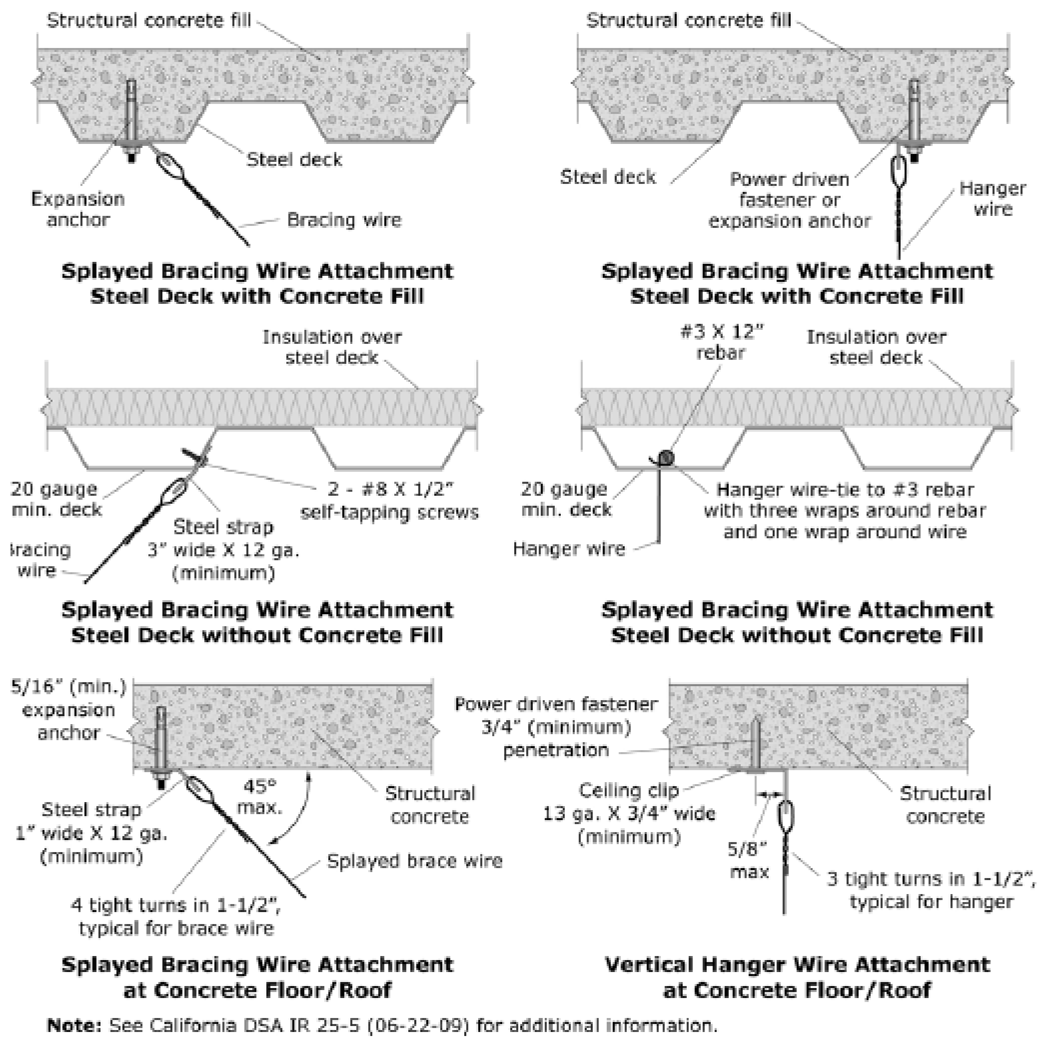
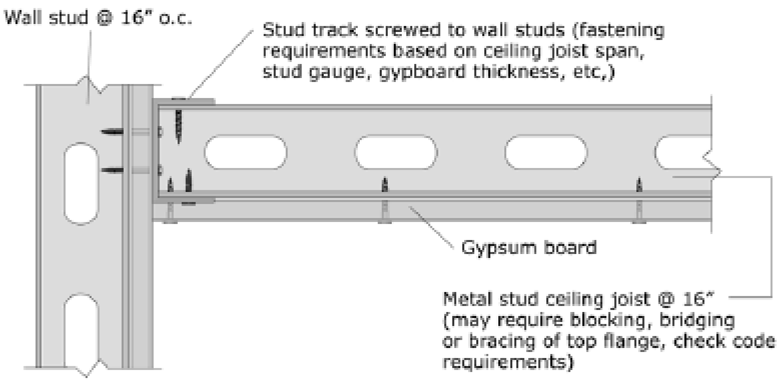
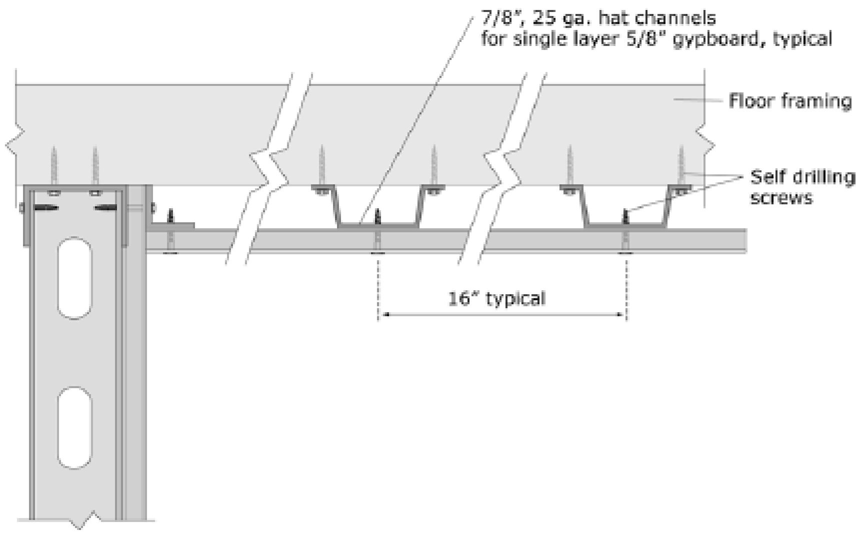


Figure G-11. Suspension System for Acoustic Lay-in Panel Ceilings – Overhead Attachment Details.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



a) Gypsum board attached directly to ceiling joists



b) Gypsum board attached directly to furring strips (hat channel or similar)

Note: Commonly used details shown; no special seismic details are required as long as furring and gypboard secured. Check for certified assemblies (UL listed, FM approved, etc.) if fire or sound rating required.

Figure G-12. Gypsum Board Ceiling Applied Directly to Structure.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

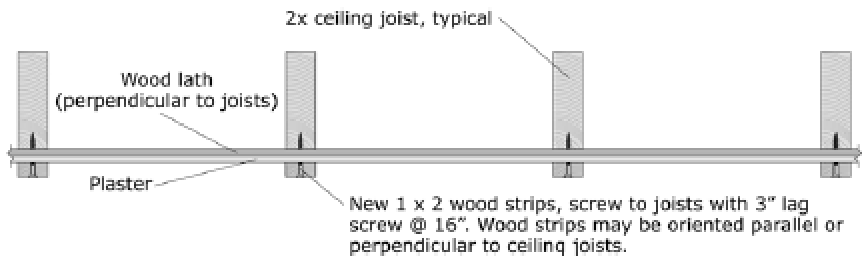


Figure G-13. Retrofit Detail for Existing Lath and Plaster.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

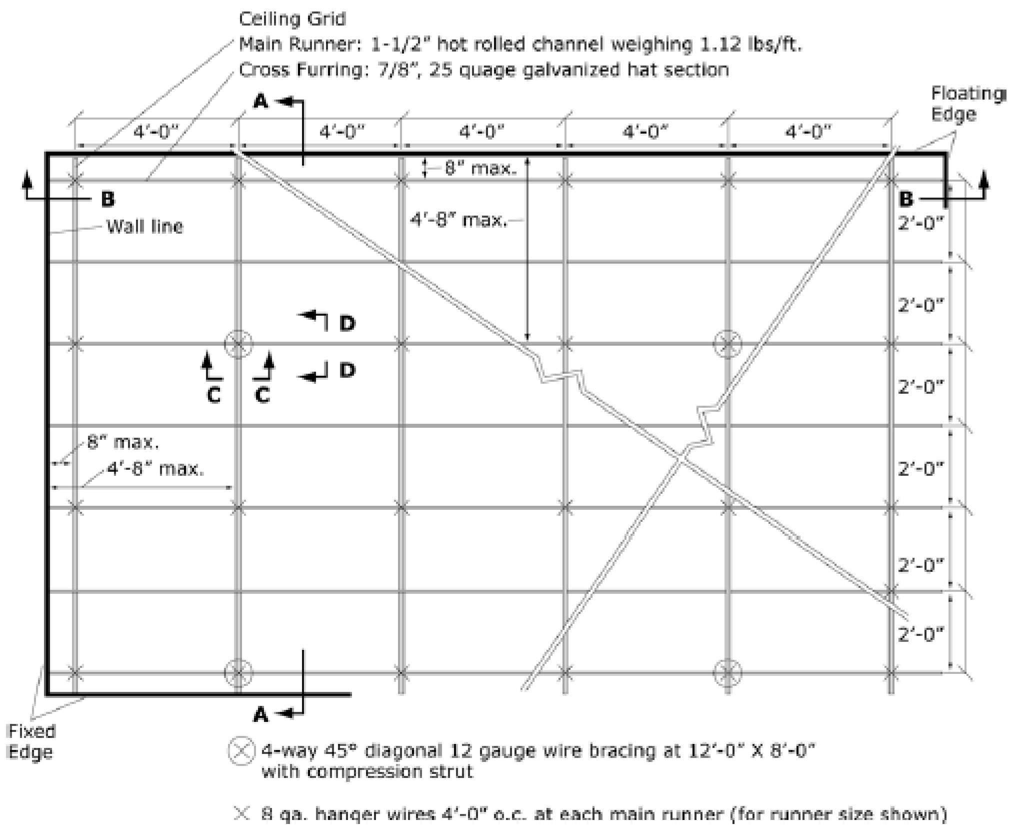
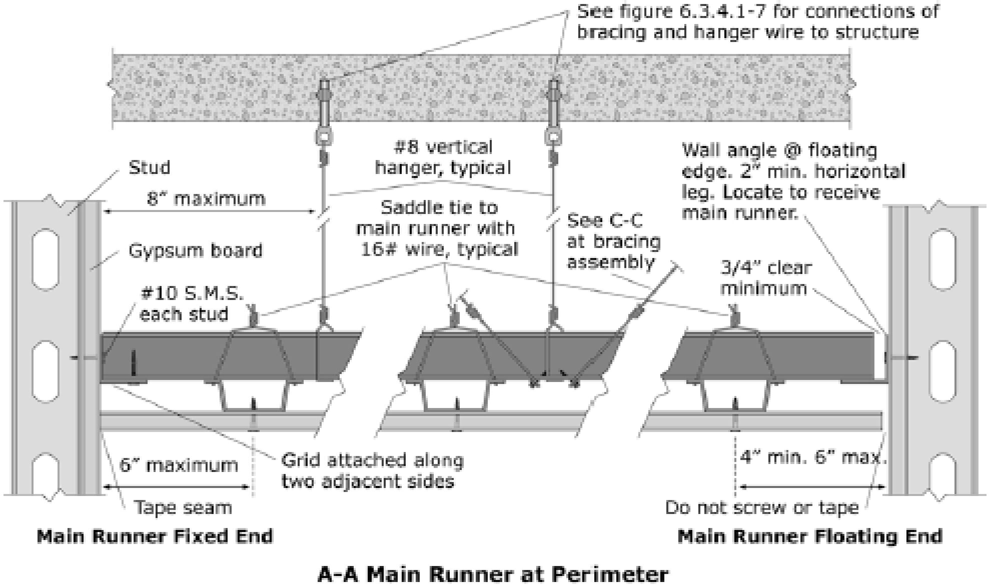


Figure G-14. Diagrammatic View of Suspended Heavy Ceiling Grid and Lateral Bracing.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



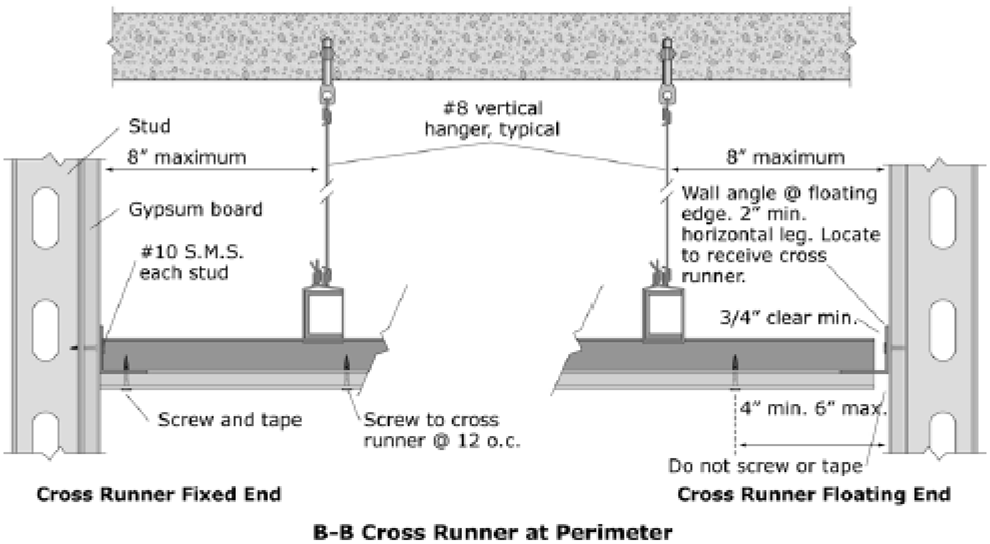
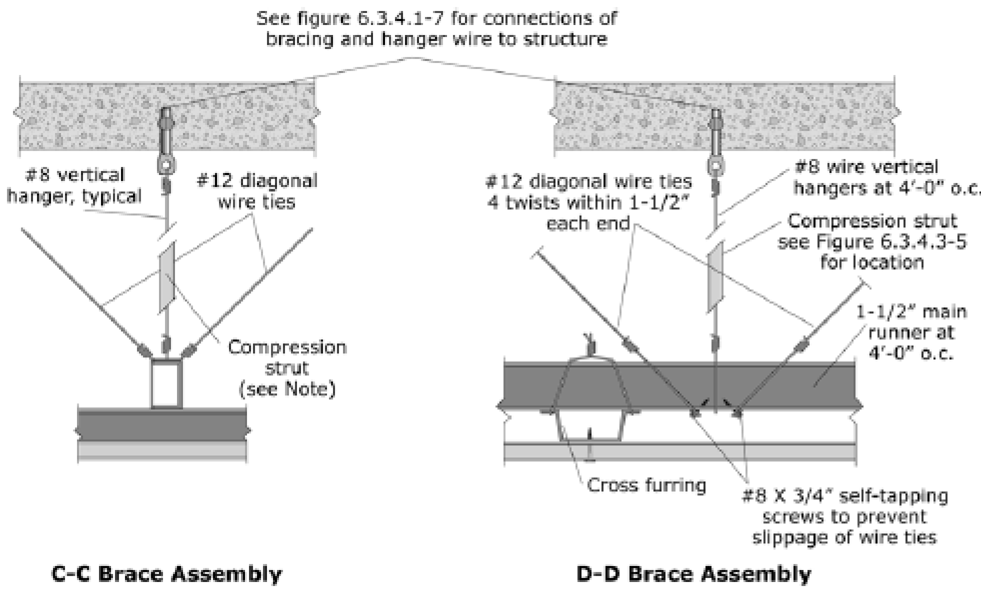


Figure G-15. Perimeter Details for Suspended Gypsum Board Ceiling.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Note: Compression strut shall not replace hanger wire. Compresion strut consists of a steel section attached to main runner with 2 - #12 sheet metal screws and to structure with 2 - #12 screws to wood or 1/4" min. expansion anchor to concrete. Size of strut is dependent on distance between ceiling and structure (l/r ≤ 200). A 1" diameter conduit can be used for up to 6', a 1-5/8" X 1-1/4" metal stud can be used for up to 10'. See figure 6.3.4.1-6 for example of bracing assembly.

Figure G-16. Details for Lateral Bracing Assembly for Suspended Gypsum Board Ceiling.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Light Fixtures

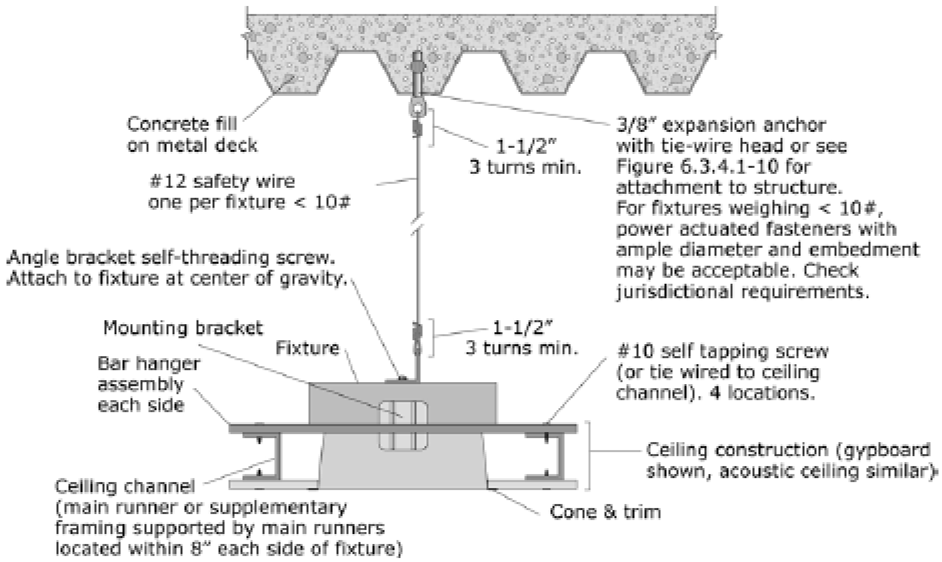


Figure G-17. Recessed Light Fixture in suspended Ceiling (Fixture Weight < 10 pounds).

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

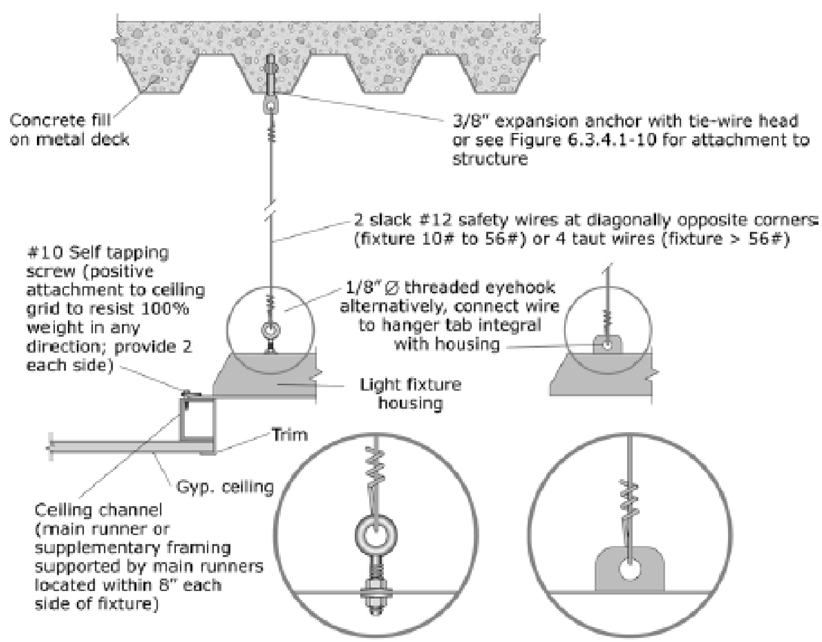


Figure G-18. Recessed Light Fixture in suspended Ceiling (Fixture Weight 10 to 56 pounds).

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Contents and Furnishings

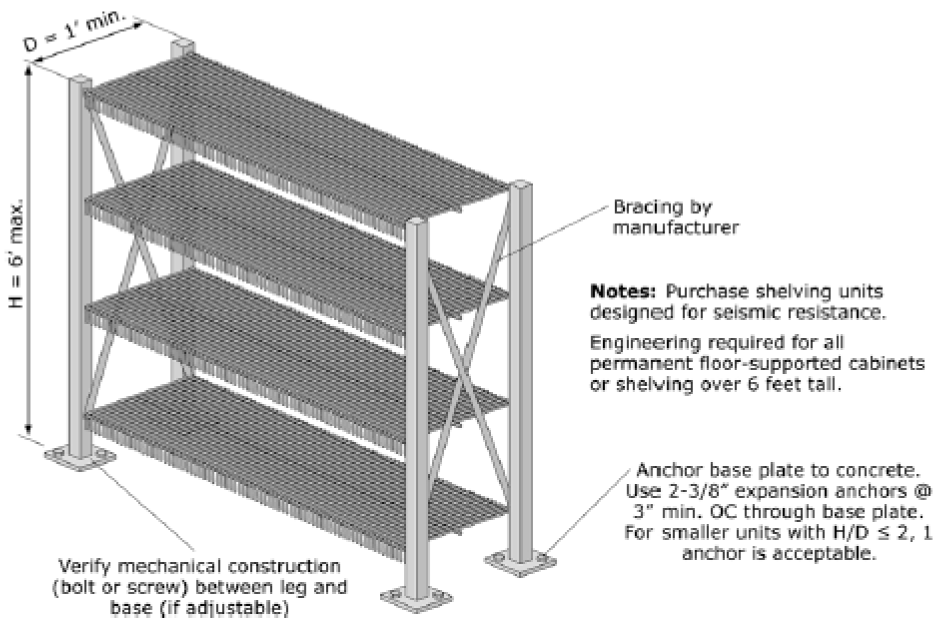
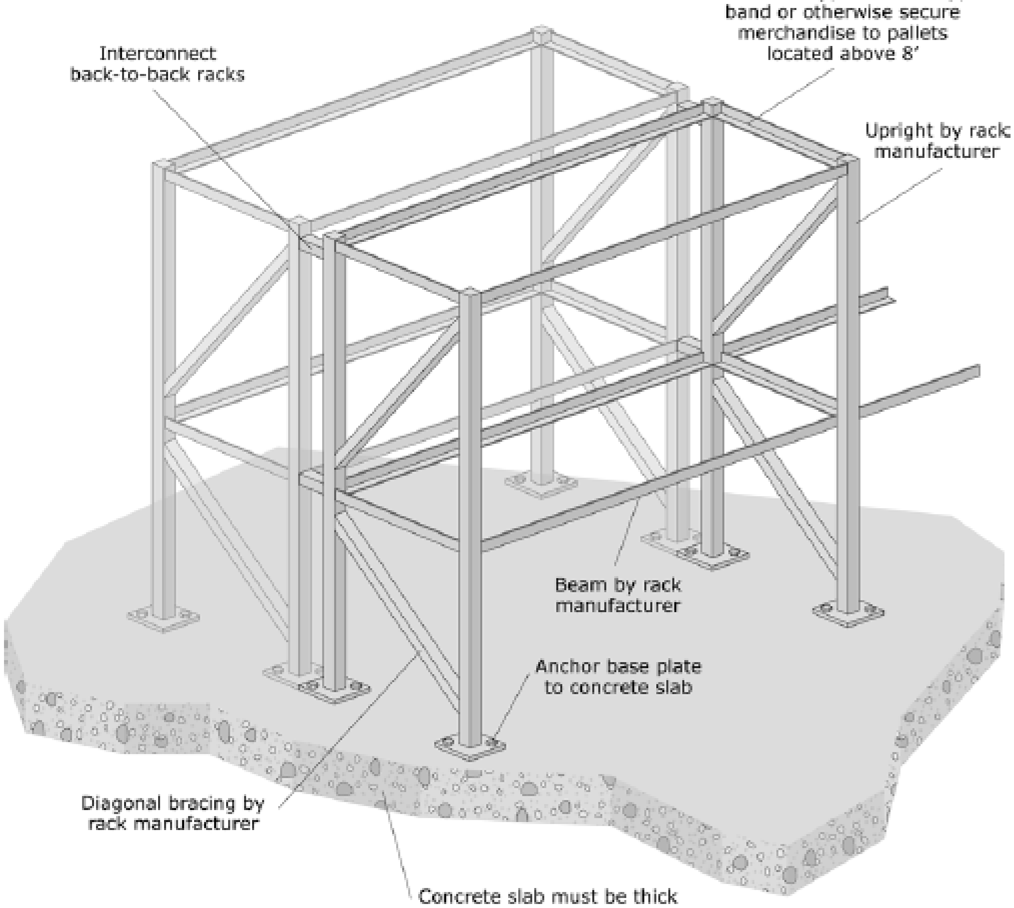


Figure G-19. Light Storage Racks.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Note: Purchase storage racks designed for seismic resistance. Storage racks may be classified as either nonstructural elements or nonbuilding structures depending upon their size and support conditions. Check the applicable code to see which provisions apply.

Figure G-20. Industrial Storage Racks.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

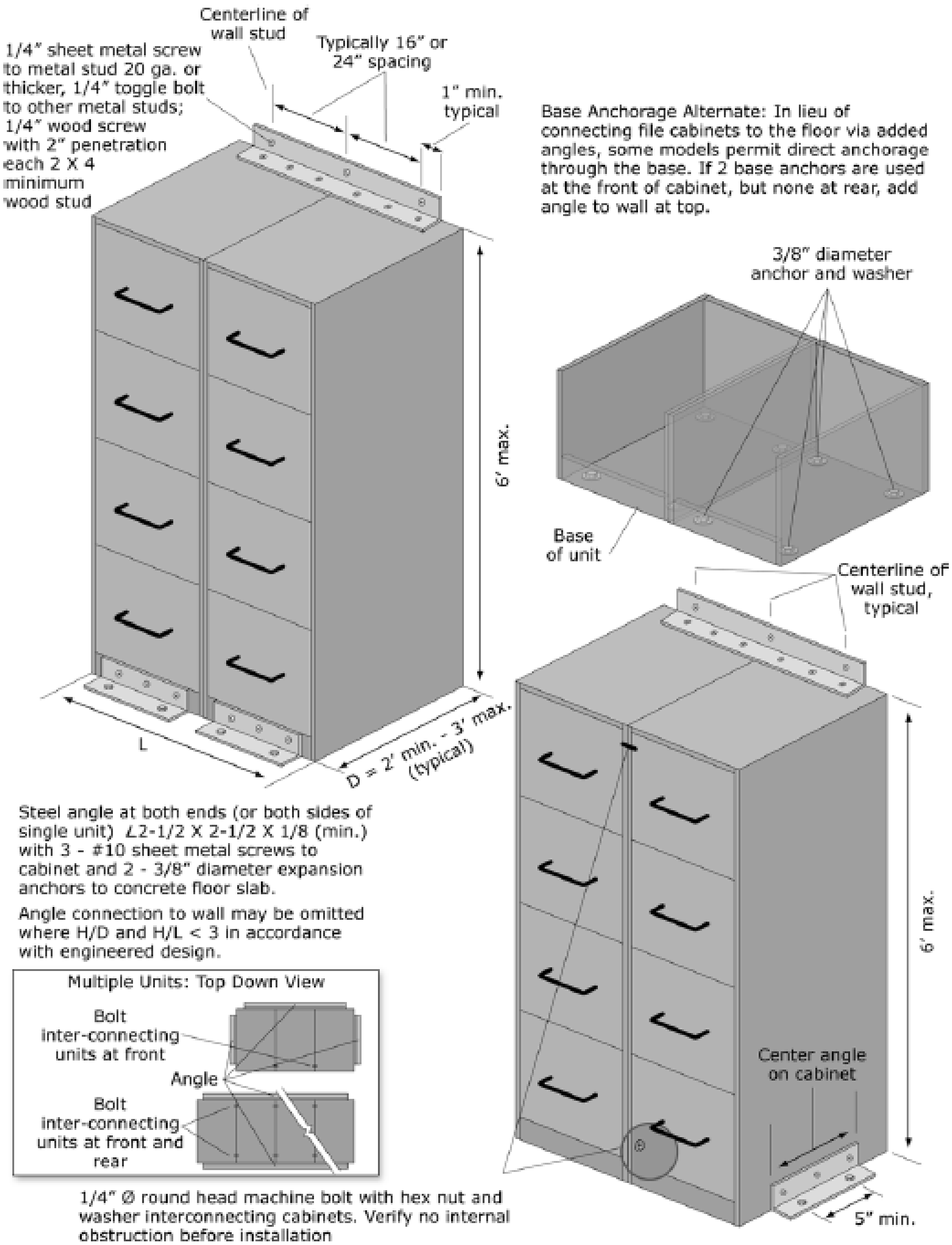


Figure G-21. Wall-mounted File Cabinets.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

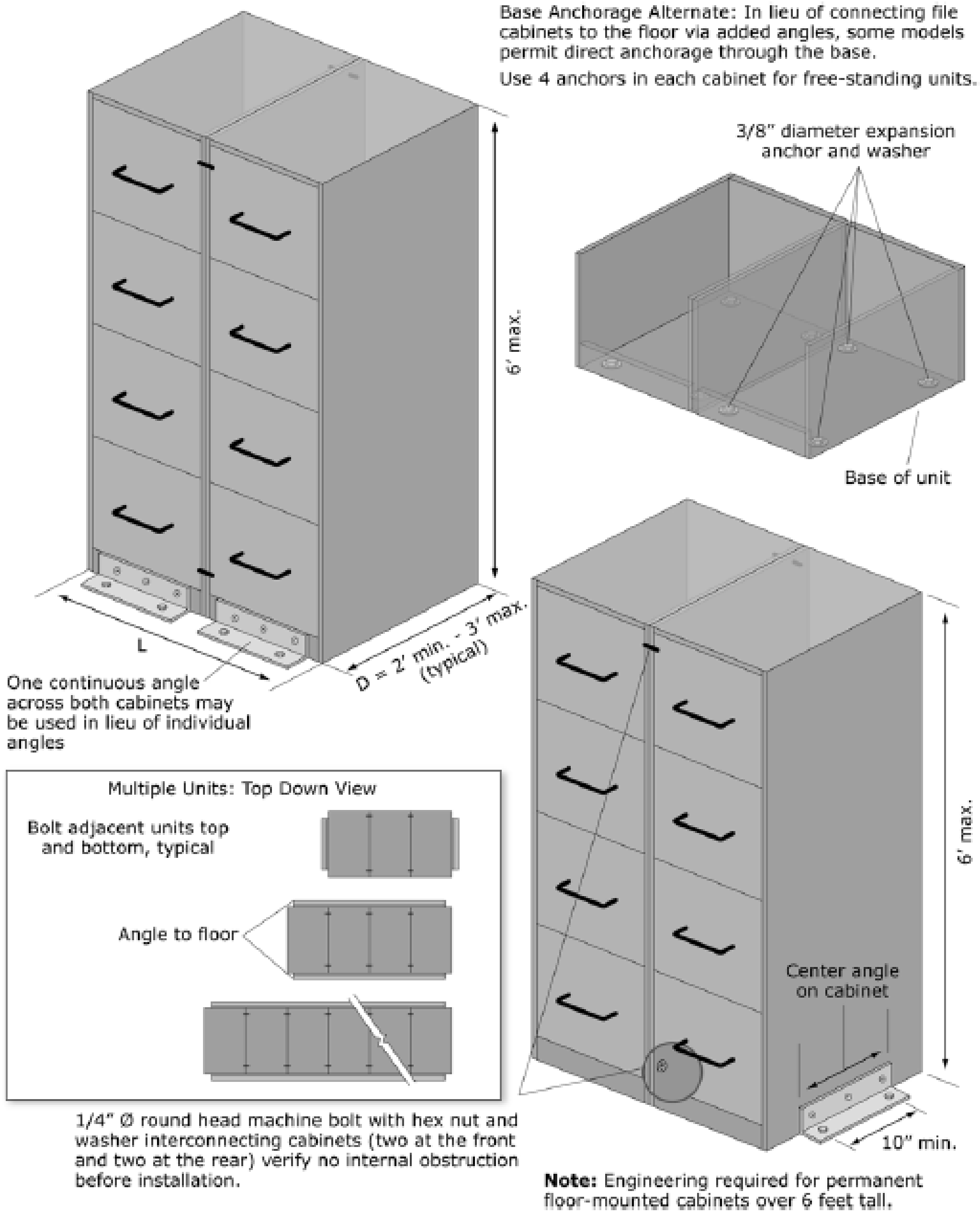


Figure G-22. Base Anchored File Cabinets.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

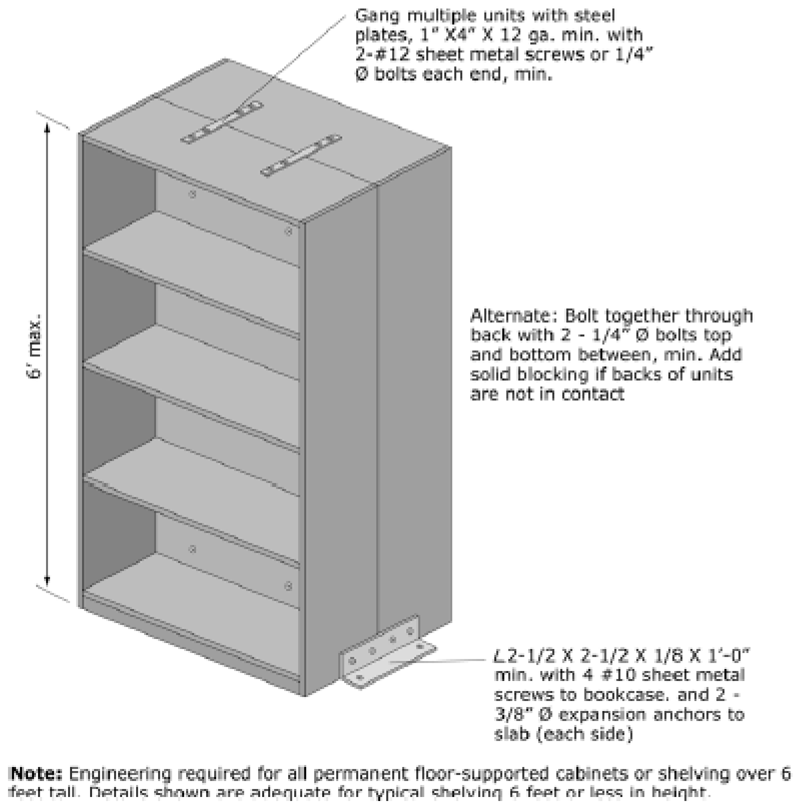


Figure G-23. Anchorage of Freestanding Book Cases Arranged Back to Back.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

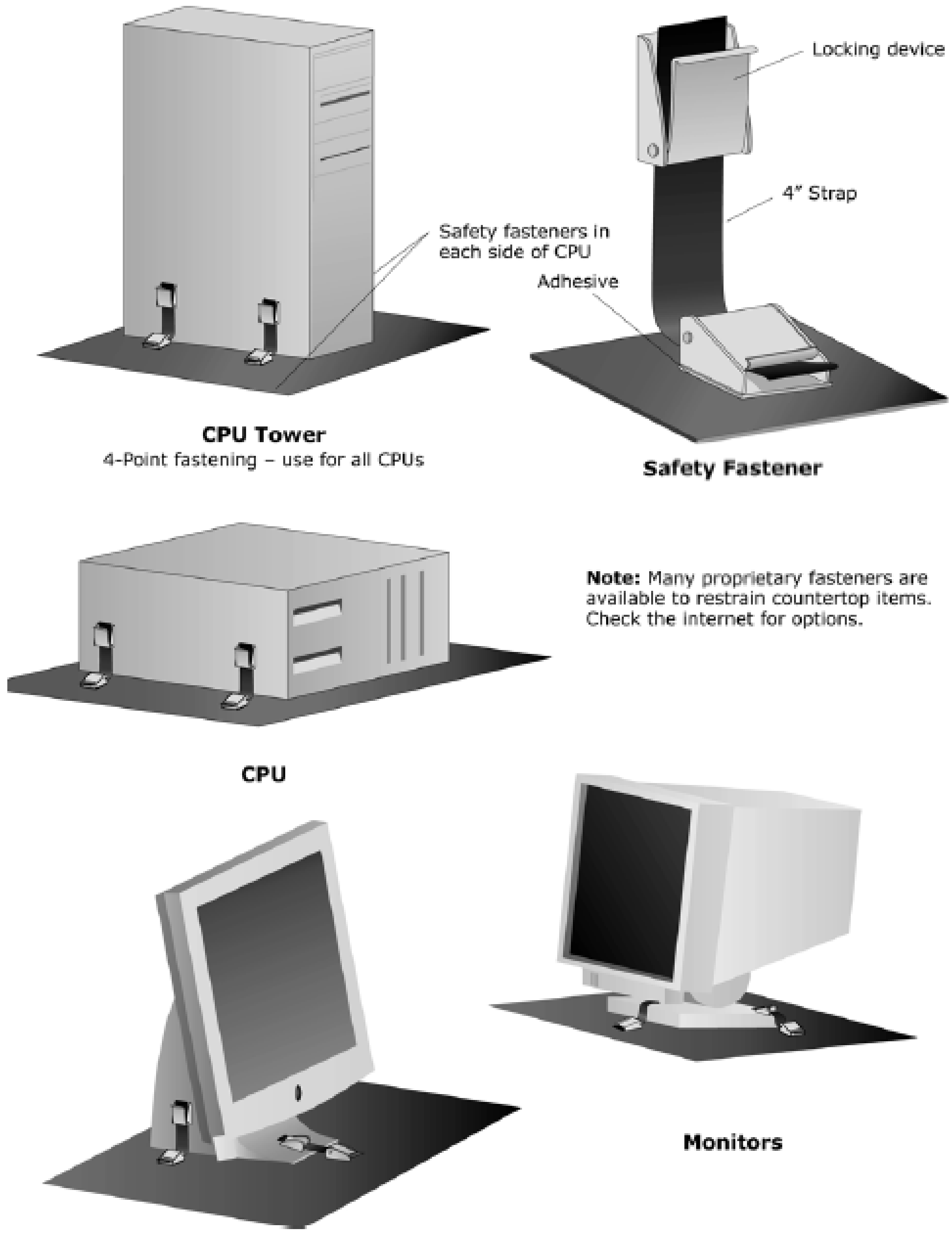
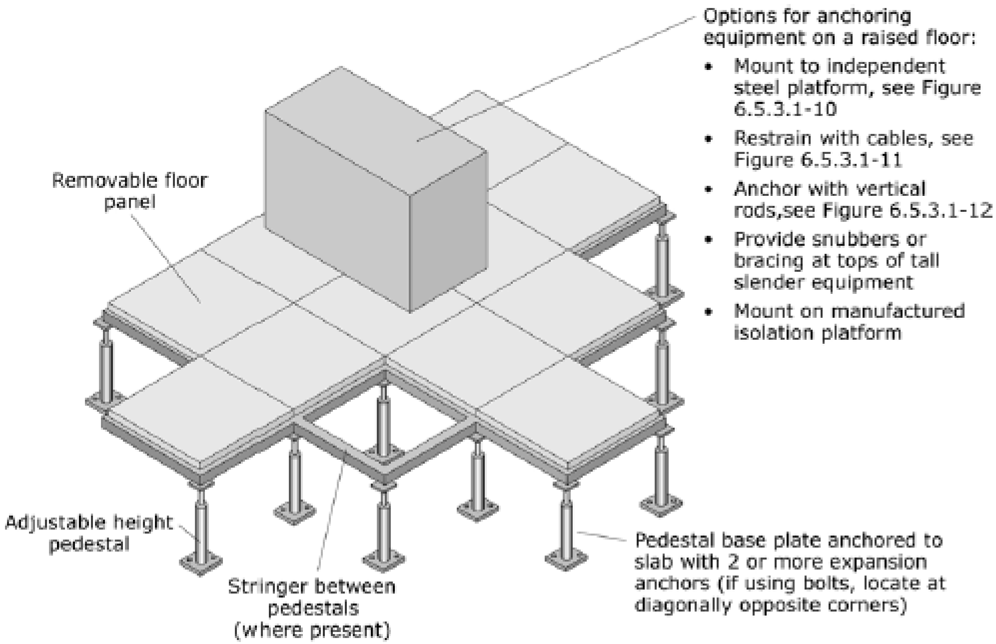
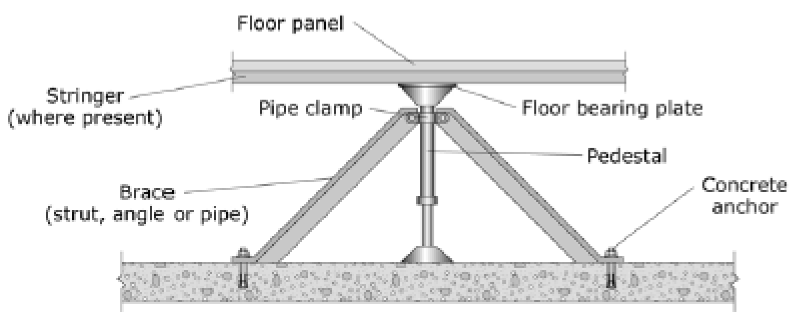


Figure G-24. Desktop Computers and Accessories.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Cantilevered Access Floor Pedestal



Braced Access Floor Pedestal
(use for tall floors or where pedestals are not strong enough to resist seismic forces)

Note: For new floors in areas of high seismicity, purchase and install systems that meet the applicable code provisions for "special access floors."

Figure G-25. Equipment Mounted on Access Floor.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

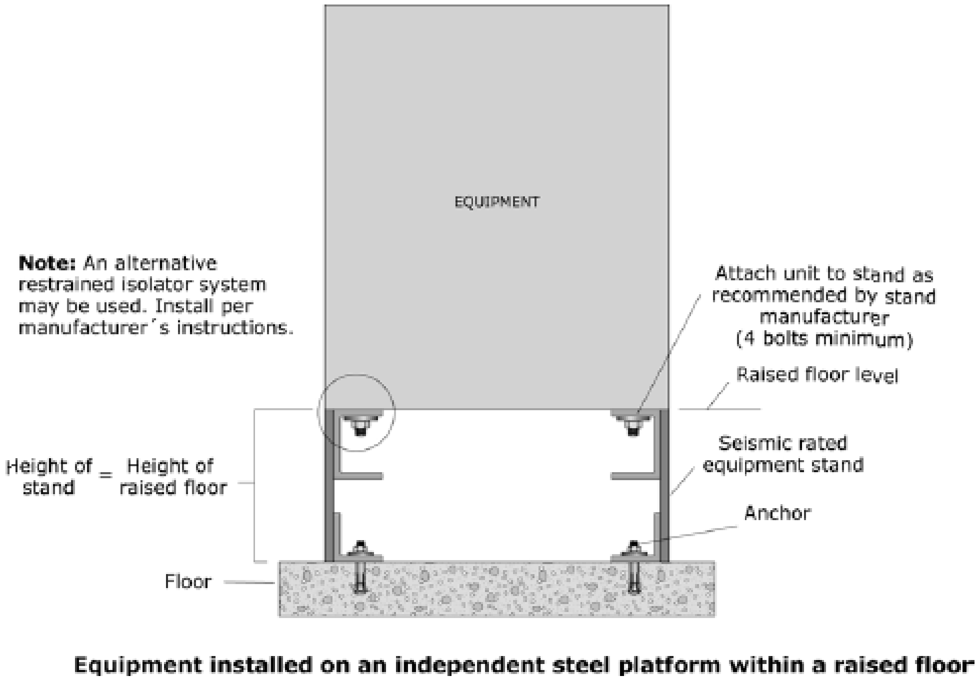


Figure G-26. Equipment Mounted on Access Floor – Independent Base.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

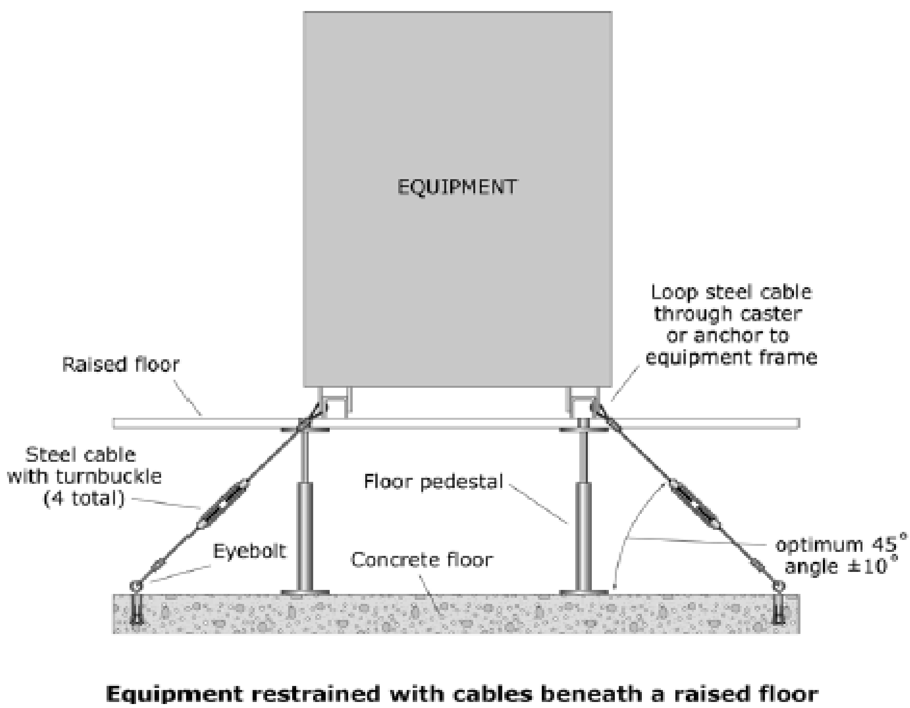
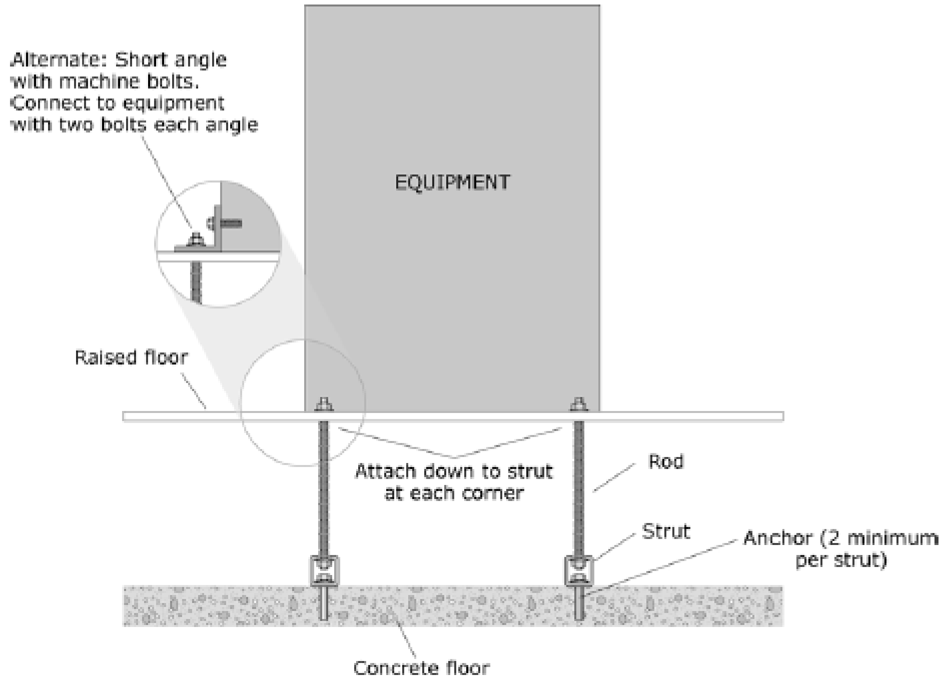


Figure G-27. Equipment Mounted on Access Floor – Cable Braced.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

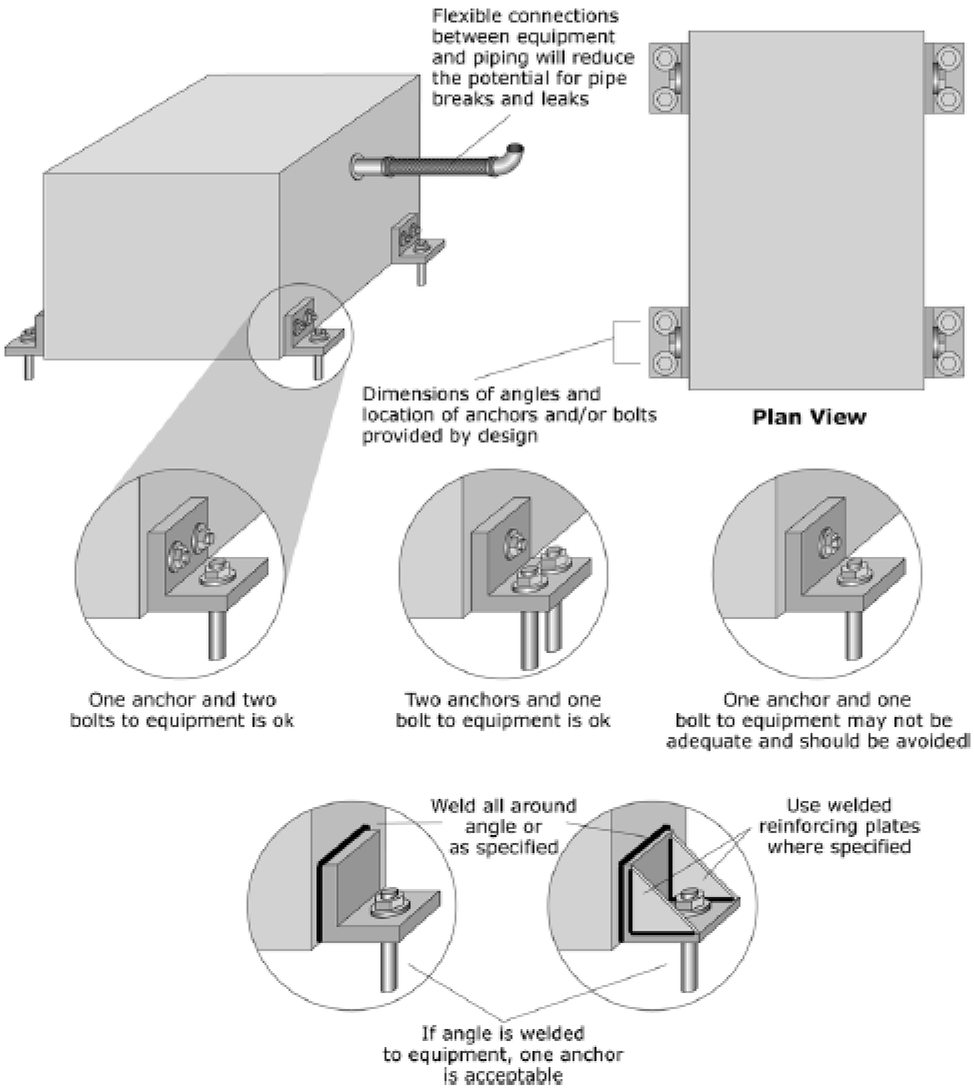


Equipment anchored with vertical rods beneath a raised floor

Figure G-28. Equipment Mounted on Access Floor – Tie-down Rods.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Mechanical and Electrical Equipment



Note: Rigidly mounted equipment shall have flexible connections for the fuel lines and piping.

Figure G-29. Rigidly Floor-mounted Equipment with Added Angles.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

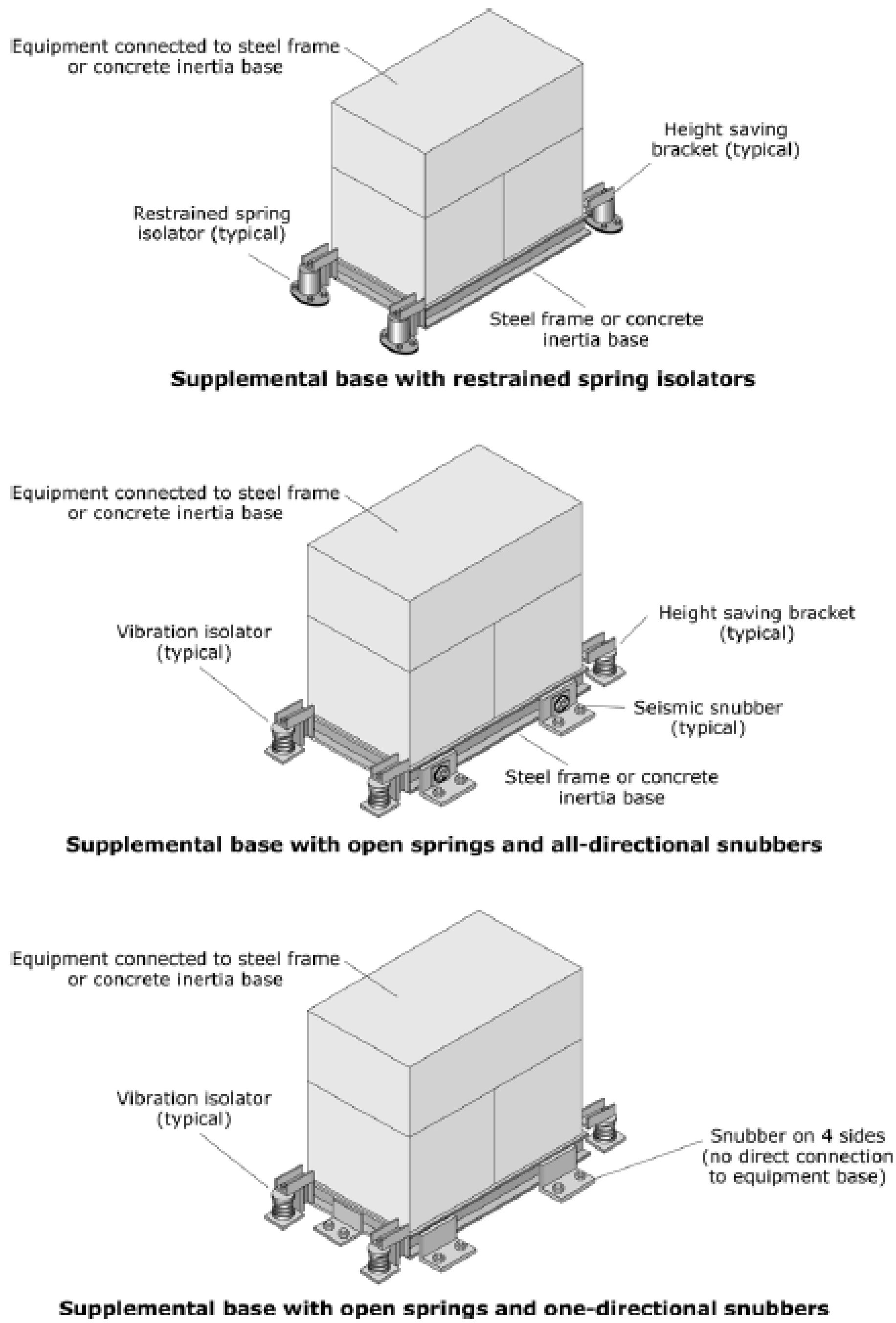


Figure G-30. HVAC Equipment with Vibration Isolation.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

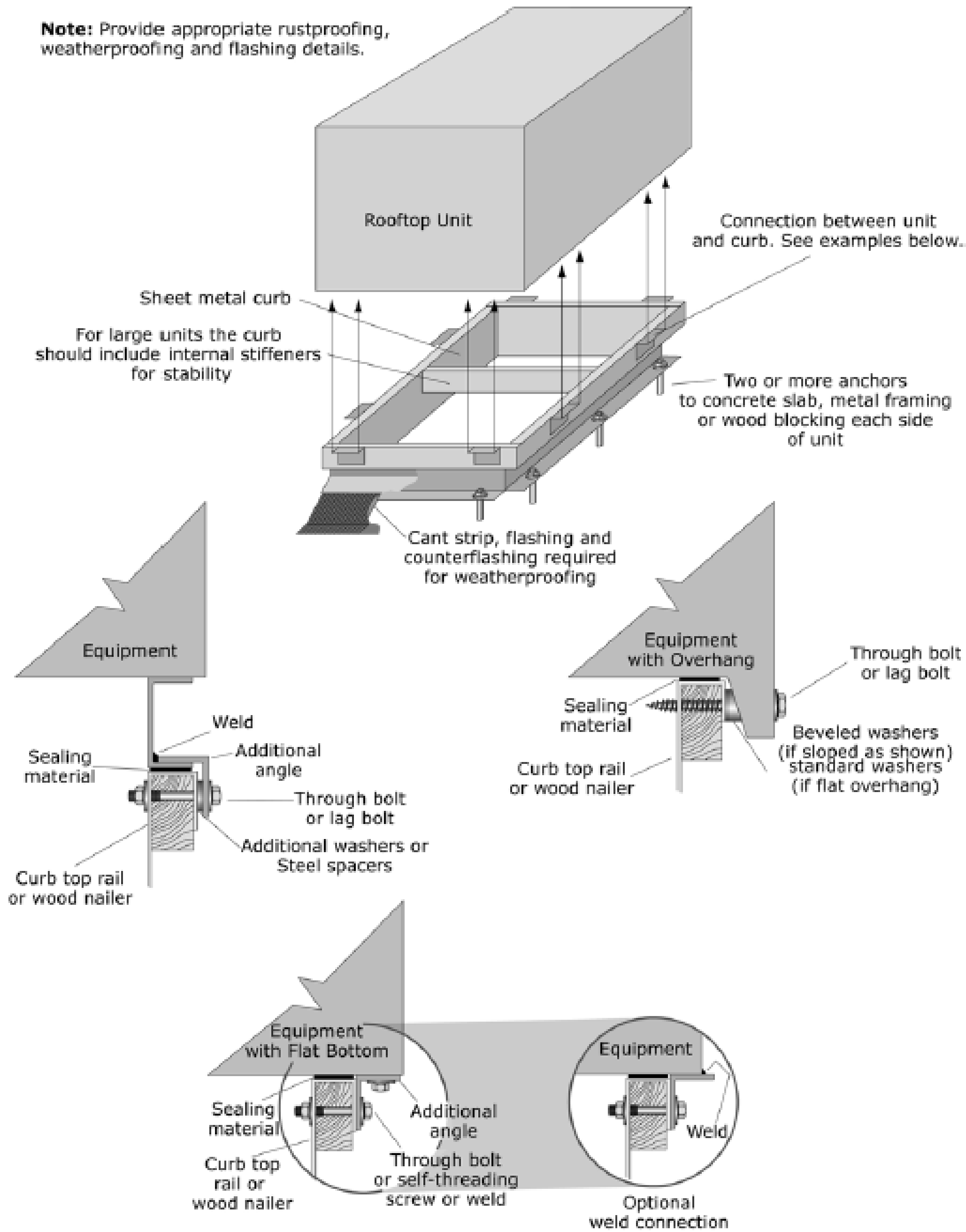


Figure G-31. Rooftop HVAC Equipment.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

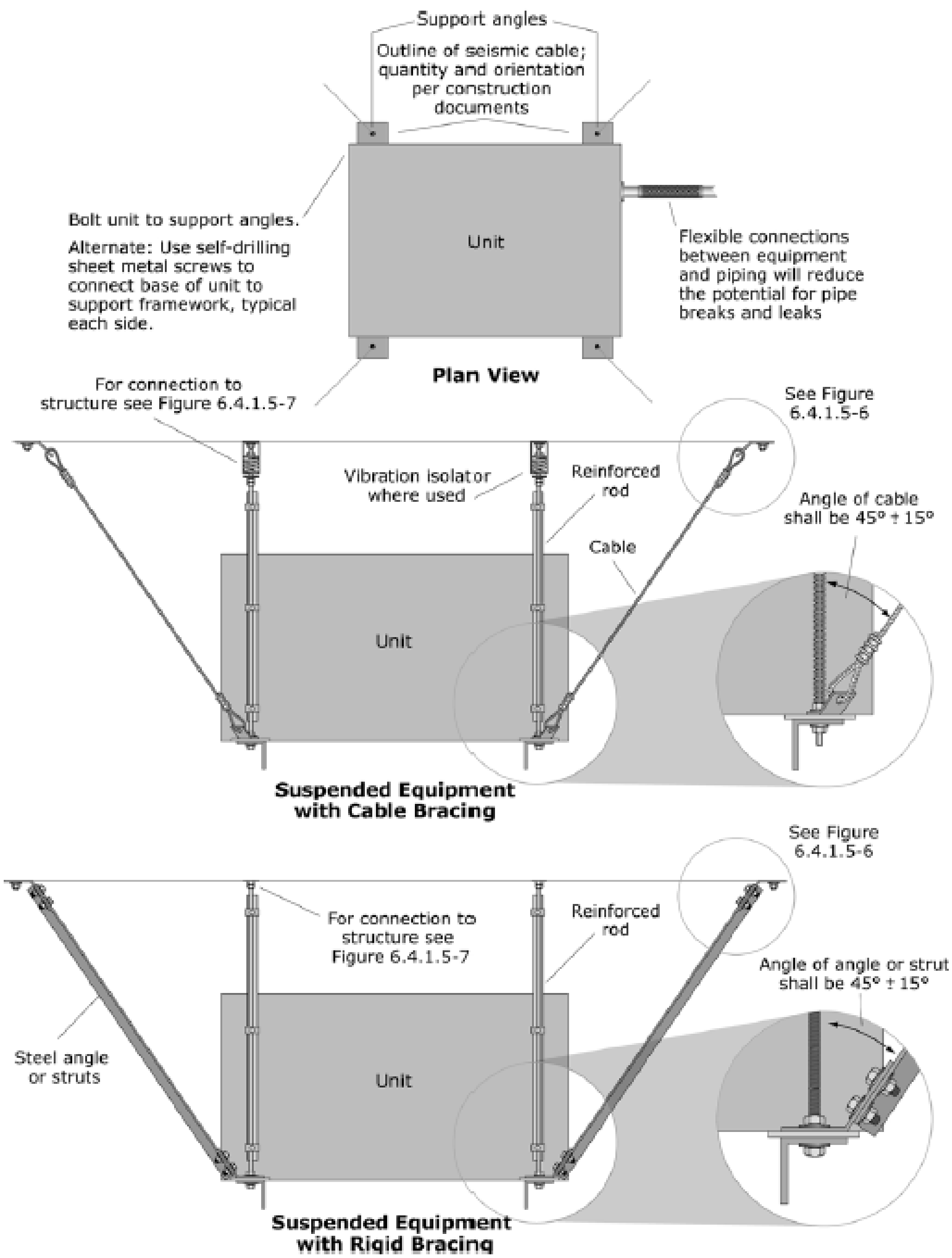


Figure G-32. Suspended Equipment.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

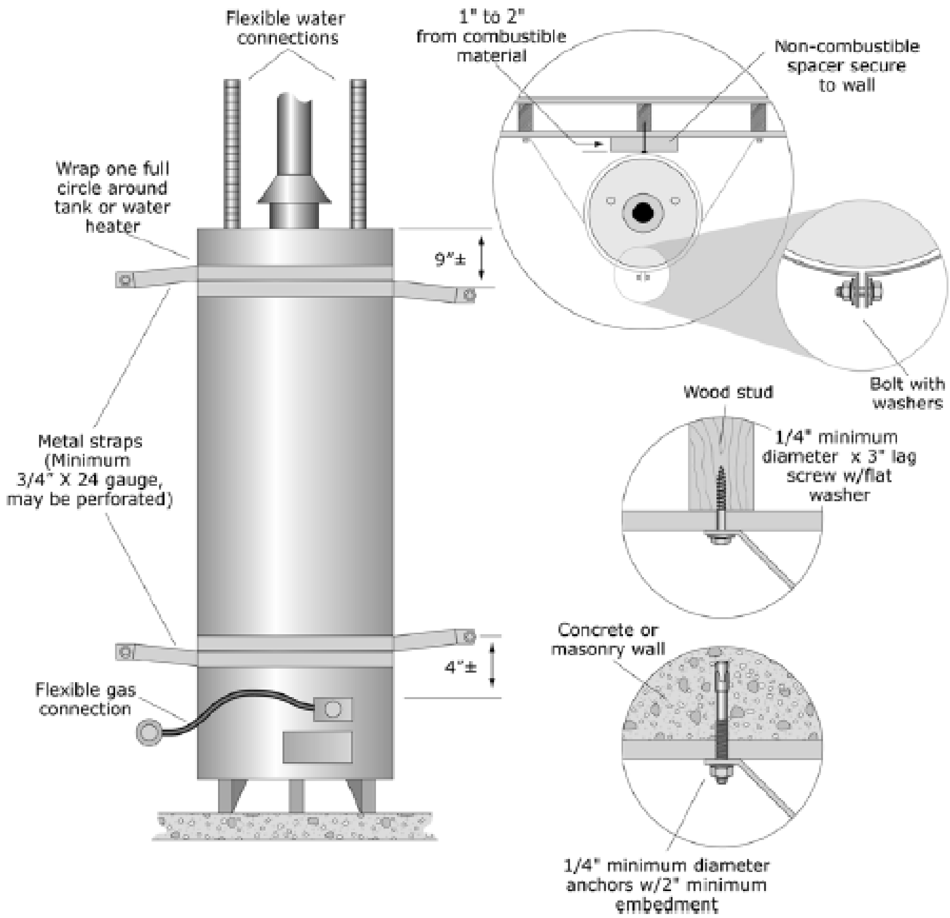


Figure G-33. Water Heater Strapping to Backing Wall.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

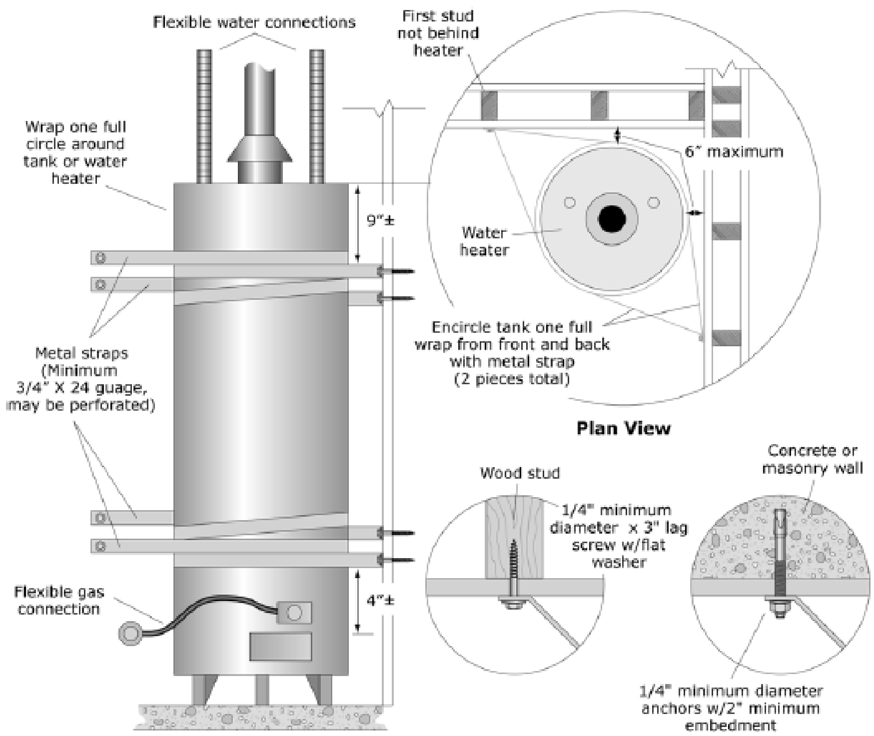


Figure G-34. Water Heater – Strapping at Corner Installation.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

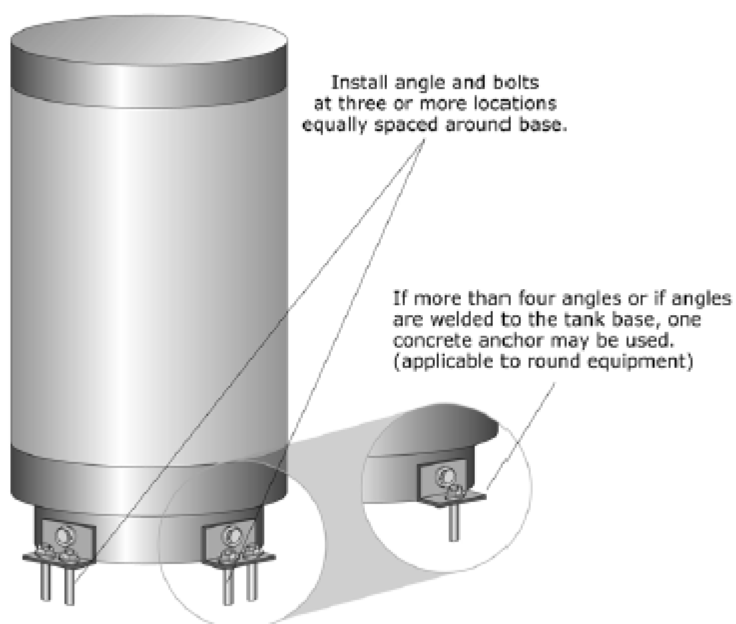


Figure G-35. Water Heater – Base Mounted.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

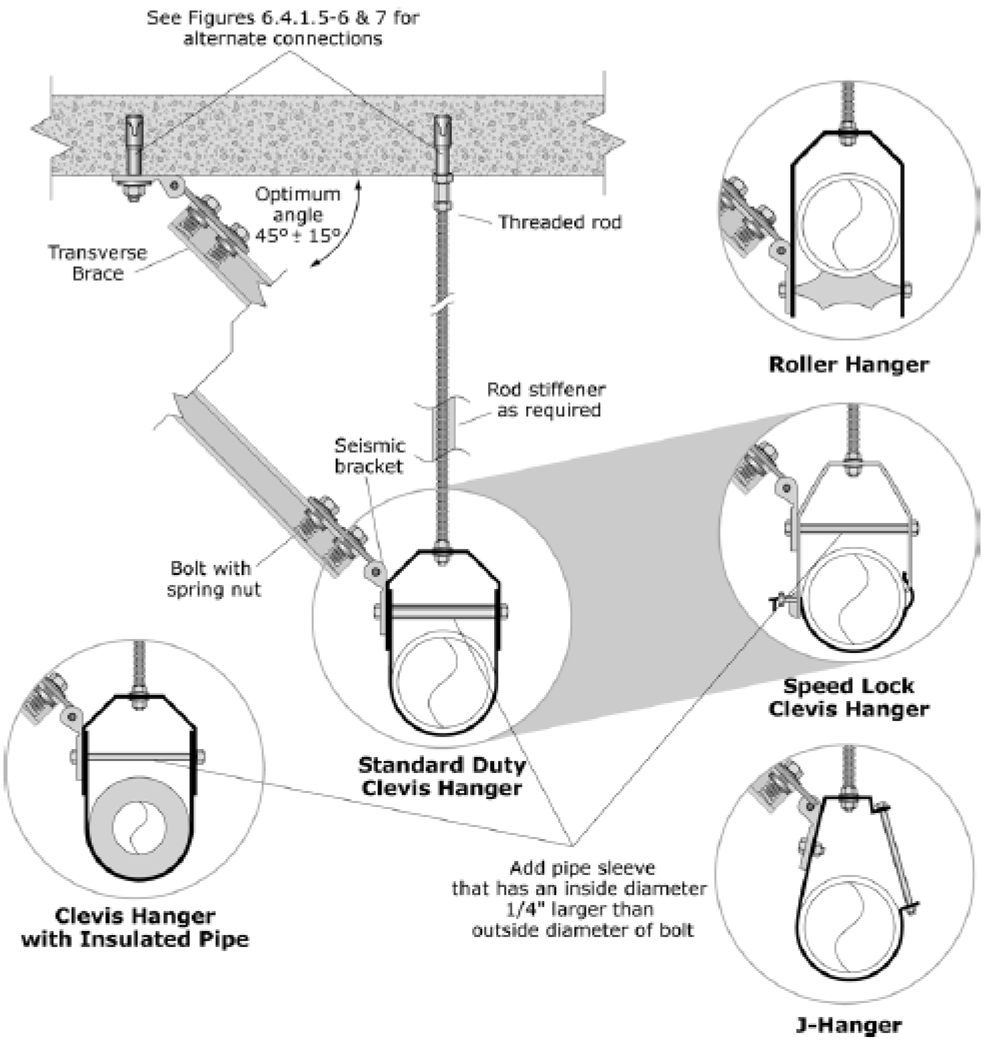


Figure G-36. Rigid Bracing – Single Pipe Transverse.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

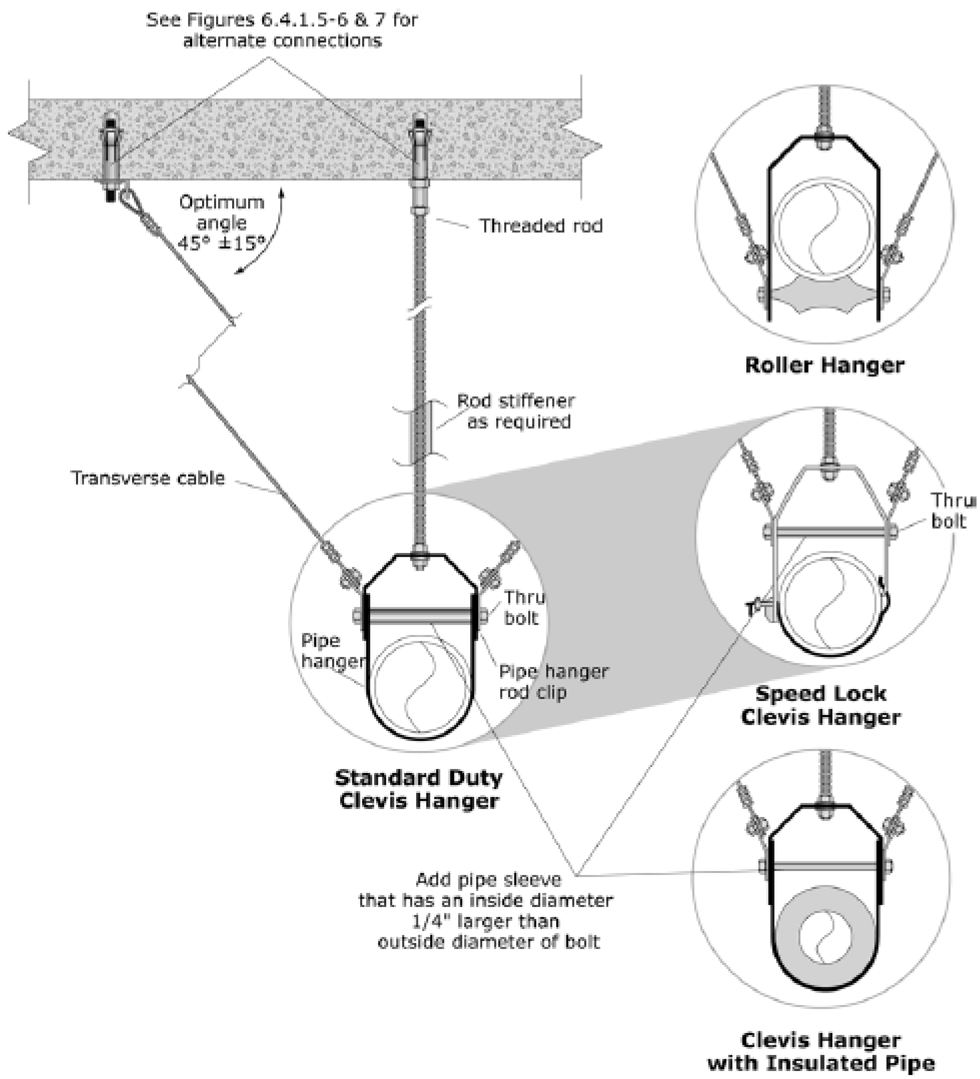


Figure G-37. Cable Bracing – Single Pipe Transverse.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Electrical and Communications

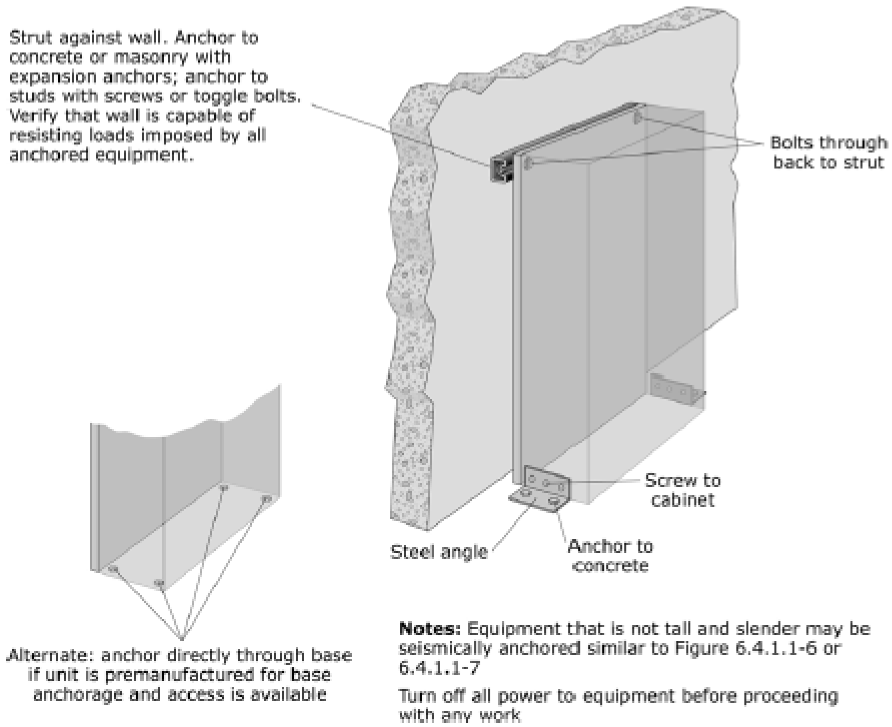


Figure G-38. Electrical Control Panels, Motor Controls Centers, or Switchgear.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

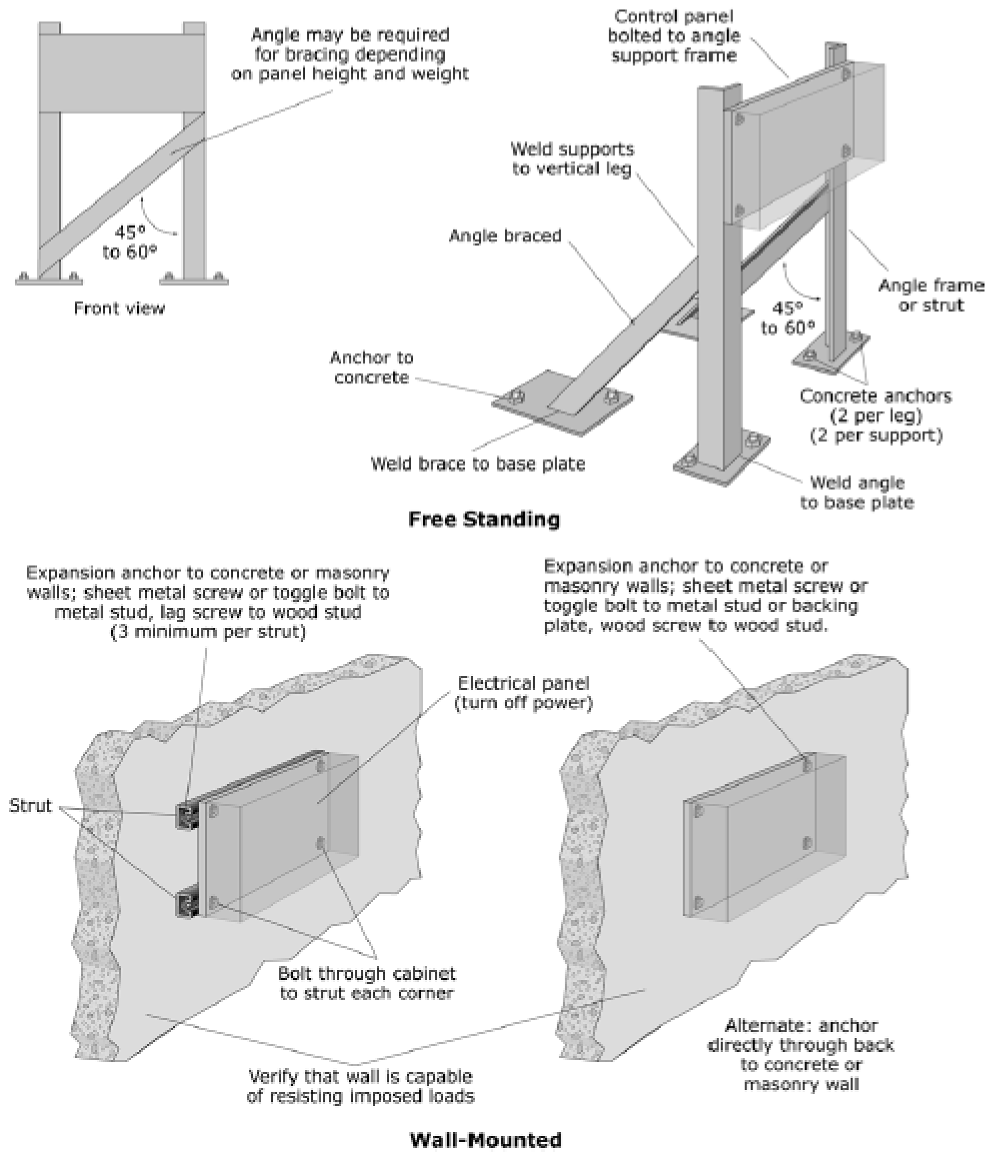


Figure G-39. Freestanding and Wall-mounted Electrical Control Panels, Motor Controls Centers, or Switchgear.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

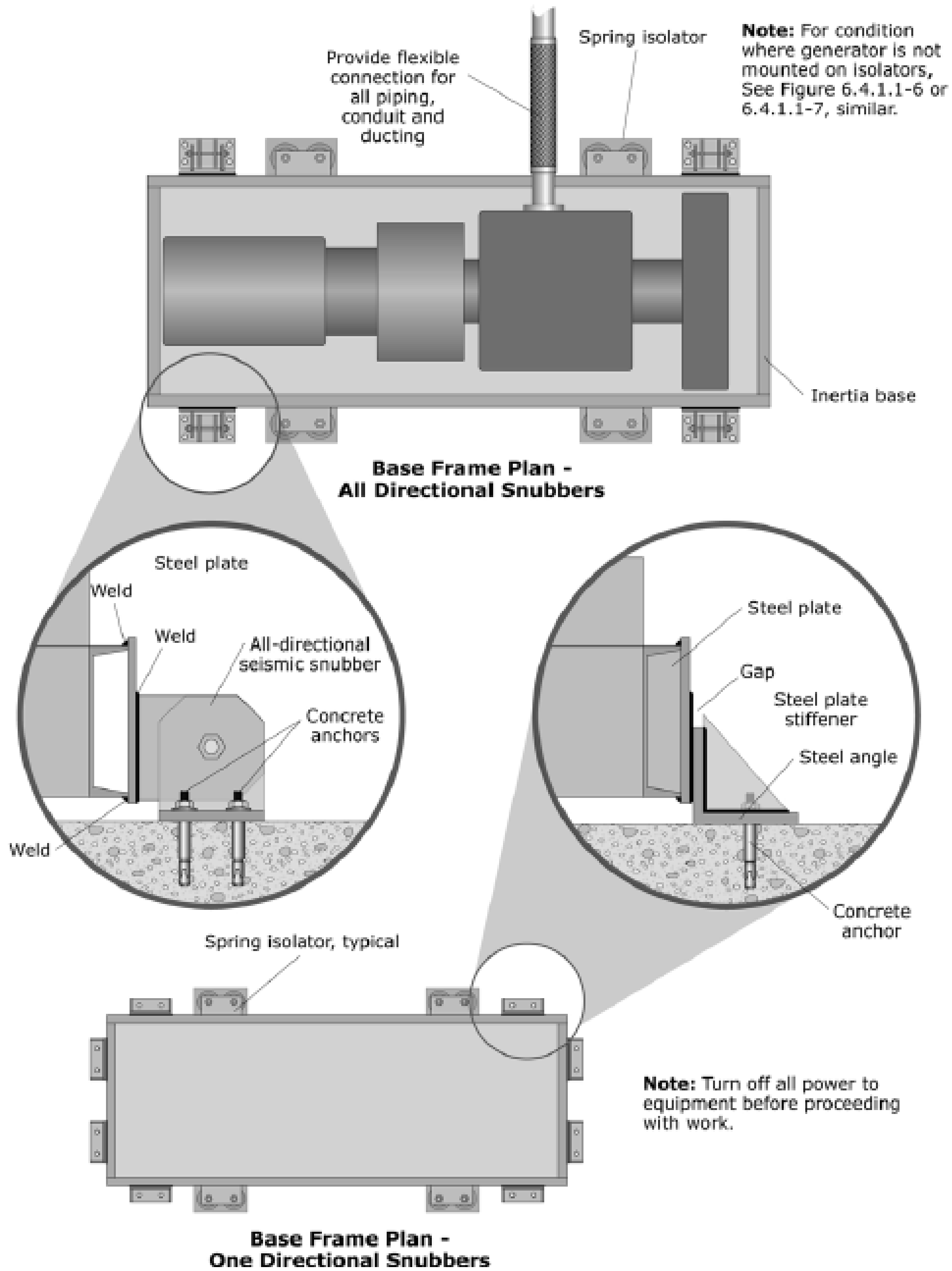


Figure G-40. Emergency Generator.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)